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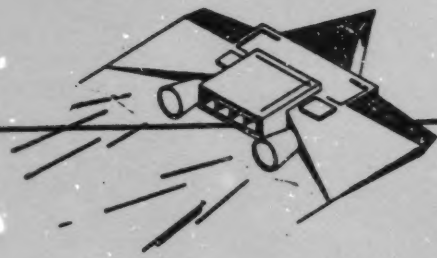
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ABSTRACT

These proceedings contain presentations from a conference whose major topics were real-world intelligence, artificial intelligence, and linkage between the education and corporate sectors. "People, Perspectives...Potential and Possibilities" (Elyse S. Fleming), which was the conference's closing speech, briefly summarizes the information presented at the conference. "New Directions toward Understanding 'Real World' Intelligence" (Robert Sternberg) suggests ways to broaden one's conception of intelligence. "Getting Steerage on the '80s" (Harold "Bud" Hodgkinson) looks at the increased amount that businesses are expending on educating their own work force, new alliances the public schools are making with businesses and communities, and how to form more adaptive intelligence. "The Computer as Coach: Applying Artificial Intelligence to Education" (John Gallagher) discusses a new field in computing--artificial intelligence; the implications of this kind of programming for instruction; how computers can enhance intelligence; and how computers can be a tool to better understanding intelligence. A section entitled "Excerpts" contains action session summaries, transcriptions from a sharing session, and evaluations. An appendix provides brief descriptions of the conference sponsors, lists steering committee members, and presents acknowledgements. An addendum presents summaries of a panel on "Intelligence and Schooling," which was designed to discuss variables critical to the development of intelligence. (YLB)

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INTELLIGENCE AND SCHOOLING

PROCEEDINGS
OF
CONFERENCE 2

NOVEMBER 17-18, 1983
CLEVELAND, OHIO

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PREFACE

The pace of change and the types of changes in our society have created a unique opportunity for public schools to take a leadership role in determining how to educate children and youth for the future. As we face the prospect that many existing educational programs and practices do not meet the needs of today or tomorrow, there are significant reasons to be optimistic about meeting the challenges of change.

The F.E.E. conference topics are planned to help us understand what the future will be so that we can anticipate and shape the changes. As school, community and business leaders, we can begin to see ourselves developing and determining what the trends in education should be in 5 years, in 15 years and into the 21st century.

Important ingredients for achieving the project's goals are: current information and knowledge from recognized thinkers, futurists, communicators, inventors, scientists, educators and political and business leaders; planning techniques and strategies that include creative/productive thinking; and networking so that each of us becomes a resource for the whole group.

More important and necessary to the project are the participants. The design calls for teams to represent a school district or other organization. For example, a participating school district is encouraged to send a team of three to five members including the following: superintendent, school board member, principal, teacher, interested community member.

These teams operate in various ways. During conferences, small groups composed of three to five teams focus their planning efforts

upon common needs, goals or problems. Each group has a leader and a recorder trained specifically to help participants use the problem-solving and inventive reasoning methods in the project model.

Between conferences, there is a continuing exchange of information and support among the teams. The dissemination and networking is enhanced via the published proceedings of each conference.

All participants are encouraged to evaluate all parts of each conference and to give suggestions for additional topics to be addressed through the project. An example is the use of many suggestions about information desired around the theme of Conference 3: Career Opportunities for the Future. We are aware that linkages with areas outside of education are crucial; therefore, the F.E.E. committee has been making contacts with corporate and industrial leaders and with representatives of Ohio's political leadership.

The first conference, Ignition! was held on May 5-6, 1983, and was attended by 200 representatives of school districts, institutions of higher education and civic organizations. We used that opportunity to confront change in advance of being consumed by it. We heard and learned from futurists and educators who were our major speakers ... and we began the process of long-range planning and networking.

Conference 2: Intelligence and Schooling, was held on Nov. 17-18, 1983. The three major topics were "Real-World Intelligence", "Artificial Intelligence", and "Linkage Between the Education and Corporate Sectors".

On following pages you will find these topics summarized by Dr. Elyse S. Fleming who was program chairperson of the conference.

We hope you will find the information in Proceedings both interesting and useful ... and we look forward to Conference 3 on March 29-30, 1984.

Mary Gardner
Conference Director

January 1984

PEOPLE, PERSPECTIVES...
POTENTIAL AND POSSIBILITIES

Dr. Elyse S. Fleming
Director
Center for the Study of Individual Differences
Cleveland State University

SUMMARY

by Dr. Elyse S. Fleming

(*Dr. Fleming's closure speech on November 18, 1983, was tape-recorded and transcribed for publication purposes.)

While Dr. Gallagher talked about A.I. (artificial intelligence), he did not speak about A.I. (augmented intelligence) ...and that is what we are going to need here in order to summarize all of the kinds of things that have happened over these past few days.

I would like to organize my remarks around the three P's ... these are: PEOPLE, PERSPECTIVES, and the future in terms of POTENTIAL AND POSSIBILITIES.

Let me start with PEOPLE. It seems to me that what we have had here is a celebration of the magnificence of the human mind. We have experienced together some extraordinary intellects, and we may have freed up some of our own potential by being with people like Robert Sternberg and Doug Detterman, Bud Hodgkinson, our splendid panelists and Dr. Gallagher. What we have is a very hopeful sign and a very optimistic one ... I did not start that way with you yesterday morning ... but I am optimistic now because what we have is a magnificent array of talent and abilities, and a reassurance that together, with these kinds of folks as leaders, we really will make it ... that we can create something new and something responsive to a very difficult and changing world.

Secondly, we can organize our perceptions about this conference around some of the PERSPECTIVES we have gained. We have really been exposed to some very different kinds of view about the nature of human

intelligence. In addition, our understanding of some of the variances has been increased significantly. Sternberg gave us a vision of a rather complex and magnificent intellect. Detterman prefers to see it in smaller, more manageable pieces. Gallagher has told us about how computers can enhance our intelligence and how they also can be a tool to our better understanding of intelligence. Our panelists told us about many variables that are terribly critical both as potential enhancements and as significant impediments to the development of intelligence: things like the way in which the culture impacts, the affect impacts, the experience and context impact, the environment and our expectations of it.

Last night, Bud Hodgkinson told us what we need to do to form more adaptive intelligence ... adaptive to a time of great change within our local communities, within our state, within our nation and within the world.

The last P ... and a double P ... POTENTIAL AND POSSIBILITIES. It seems to me that what we have gained together is a vision of where it is that we may be going in terms of our understanding of what approaches, tools, techniques may be available to us. What we know and need to know ... what we need to think about applying so that we can begin to confront the very critical role that we as educators will play.

We are terribly important. The world depends on us ... our minds, our meta-components that will allow us to plan, to direct, to use our abilities to help all children to learn, to think, to reason, to problem-solve, to harness that technology ... to cope ... to grow ... and to care.

Thank You.

NEW DIRECTIONS TOWARD UNDERSTANDING
"REAL WORLD" INTELLIGENCE

November 17, 1983

Dr. Robert Sternberg
Department of Psychology
Yale University

NEW DIRECTIONS TOWARD UNDERSTANDING

"REAL WORLD" INTELLIGENCE

by

Dr. Robert Sternberg

The issue I would like to address today is intelligence. What exactly is intelligence, and how does it interface with the concerns of educators? The fact that I ask the question suggests that I'm not completely happy with current views, and during the course of this talk I will discuss why that is true. Let me start off by relating an anecdote that I think will explain why I'm not totally happy with most definitions of intelligence.

When I first came to Yale as an assistant professor, we used (as we do now) the Graduate Record Examination as one of a number of criteria for determining admission of students to the graduate program. The Graduate Record Exam is a standard scholastic measure of intelligence similar to the Scholastic Aptitude Test, or SAT. During my years at Yale, we occasionally would admit students with very high scores; but when they arrived, it seemed inconceivable that the person presenting him or herself could have scored as high as they did on the test. And I often found myself wondering just what it is that the test was measuring or not measuring, that it would lead us to admit to the program a person so lacking. So, occasionally we would get people with very high test scores but very low performance. At the other extreme, we occasionally received applications from people with excellent credentials except that their test scores were low. For example, in our admissions classes two years ago a woman applied who had fantastic letters of recommendation from very well-known people in the field of psychology; this woman had research publications, and the letters of recommendation indicated she

was primarily responsible for the publications; and she had very respectable transcripts and other credentials.

The one problem with this applicant's record was the low test scores. After a long discussion of the case, this applicant was not admitted. But in such cases, there was always one person on the admissions committee who voted for the admission. Unfortunately, there usually is no follow-up in such cases. The applicant not only fails to get into Yale, but also is not accepted into other comparable schools; so you never know whether the person would have been successful at Yale or not. This case was the exception because the individual applying happened to be my research associate at the time. When this woman was not accepted, she decided to take the first year pro-seminar and also an advanced seminar course as a special student. In the advanced seminar course she was the best student in the class, and in the pro-seminar, one of the best. So in this rare case where there was a follow-up, it became clear that the test wasn't a good predictor and that the other credentials were more accurate. The next year this woman applied and was admitted to Yale, as well as to other schools of comparable quality. If you get some people with high test scores who in various ways don't perform well and you get some people with low scores who do perform well, what exactly is missing on the measurement instrument? The answer might be that intelligence tests don't and can't be expected to measure personality, motivation, and so on. But that brings one to the position essentially of Boring, who said that intelligence is what the I.Q. test measures. That definition is lacking from a psychological as well as an educational point of view. So the question I want to address is what is intelligence? But before giving my own view on it, I want to give a bit of background.

The major devices used today to measure intelligence are the so-called I.Q. tests. But how do we know they measure intelligence? Well, they are based on psychometric theories of intelligence, which are

theories that date back to the early 1900's and are statistically based on a technique called factor analysis. Factor analysis takes a series of tests -- such as vocabulary, verbal analogies, classification problems, reading comprehension and so on -- and transforms the data from these tests to identify the underlying latent structures and factors of intelligence, or at least that's what many people believe. But there are several caveats that are important to be aware of, not the least of which is sometimes referred to as the input-output problem, and that is that factor analysis can only give a transformation of what goes in. In other words, those latent abilities can only reflect the particular tests that were chosen to be included in the factor analysis. So clearly an important question is why do we choose these particular tests -- for example, the ones I mentioned -- rather than some other tests? And if one goes back into the psychometric literature, it is usually found that the tests were selected because they had been found to be useful in previous factor analyses and in previous psychometric studies. But since that would not be, in itself, sufficient criteria to use that test, one must go back further to Spearman and Thurstone and others of the very earliest psychometric investigators. It then becomes clear that they weren't quite sure what tests to put in, but rather did it pretty much on a hunchy basis. So what we find is that from a theoretical standpoint, there hasn't been much reason for selecting those tests as opposed to some others. That is not to say that the tests are either the wrong ones or the right ones, but rather that it would be nice if there were some theory which suggested that some particular tests are the tests we should use when we want to measure intelligence.

Well, in the 1970's a new breed of researchers became aware of this problem and decided it was time for a change. Their particular concern was with the failure of traditional theories and tests to identify the properties of intelligence. When a person is performing well, either at school or in the everyday world, what thought processes are occurring that lead to their success? This question is particularly important

because it is now clear that one can get the same products -- the same observable responses -- from quite different mental processes. So these investigators -- information processing investigators -- started what they believed (and I was one of them) to be a revolution in the theory of intelligence. There were what you might call two "camps" of these investigators. The one to which I did not belong was the so-called cognitive correlates camp. This group of investigators took the tests that experimental psychologists were studying, which related to the material on I.Q. tests. The kinds of tests they looked at were things such as letter comparison. For example, you would see on a computer display a capital A and a small a. You might be asked to indicate as quickly as possible whether these two letters match in name, or you might be asked to indicate whether the two letters were instead a physical match. The results of these tests were believed to be important for understanding cognitive functioning. A typical finding from these tests was that speed on the various parameters as correlated about .3 with scores on I.Q. tests. Well, .3 is on a scale of 0 to 1, where 0 is low and 1 is high, and that seems not to be terribly promising, but the idea that these investigators believed was that these very simple tests showed at least some relationship to intelligence.

Some tests were even simpler than letter comparison. For example, Arthur Jensen is using a choice reaction where you see a display with a varied number of lights and your finger is on a button. As soon as one of the lights goes on, you must take your finger off the first button and press on the light, which turns it off. So I think you can see this task and others like it are quite simple.

I wasn't very happy and still am not happy with the cognitive correlates approach for a number of reasons. One is that the tests seemed too simple; if we want to understand high-level intelligence, we're going to have to look at more complicated things than choice reaction time. Further, correlations with the tests for which the processes underlying these tasks were supposed to be casual elements just weren't

very high. A correlation of .3 on the 0 to 1 scale just isn't very exciting in terms of giving us any kind of casual explanation. But the biggest problem from my point of view was that the psychologists were using these tests because they happened to be the ones that cognitive psychologists were studying in their laboratories. However useful the tasks may have been in the study of perception and learning and memory and so on, it wasn't at all clear that these were the right tasks to be used in the study of intelligence. That's where the second camp of investigators comes in. What people like myself and other did -- we were the so-called cognitive-components school -- was to study the tests that appear on I.Q. exams, like analogies and classifications. But instead of analyzing the factors, we tried to uncover the mental processes that underlie performance on the tests. And in that we were pretty successful. In other words, we could take, say, an analogy and we could tell not only the amount of time a person spends on each of a variety of mental processes, but also how accurately they could perform those processes. The advantage to this was that rather than getting just a global score for reasoning or I.Q., one could obtain from each person a score for each of the processes that give rise to this total or global score. This seemed like an advance at the time, and I still think that's true. Recently, I've become less happy with this approach, as well, because it seems to suffer from the same problem I've referred to before: whereas the so-called cognitive correlates researchers had taken the tests that experimental psychologists happened to use, we were taking the tests that I.Q. testers happened to use, and there was no really good evidence these were the right tests either.

The question I would like to turn to now is just what intelligence is, apart from the question of any specific task. We need to start with a theory, and only then to choose a test on the basis of that theory. The theory I propose I will call a Triarchic Theory of Intelligence, because it has three major parts to it. What I would like to do is convince you that a reasonably complete theory of intelligence has to be

comprised of at least three parts. Let me first give you an overview of the theory. Basically, the claim is that in order to understand intelligence, you must understand three things.

The first is the relation of intelligence to the internal world of the individual. In other words, what goes on inside a person's head when he or she is behaving in an intelligent fashion? What are the mental processes? How do these combine into strategies? What kinds of mental representations are used for understanding the information? And so on. These are the kinds of questions the cognitive researchers have been addressing. In other words, what are the processes of intelligence? This is the approach with which I was quite happy until the last several years, when I began to realize that although this approach was telling us the mental processes it was for the very same tasks that had been used on I.Q. tests. So it seemed that something more was needed.

One "something more" is that a theory of intelligence has to specify not only the relation of intelligence to the internal world of the individual, but also the relation of intelligence to the individual's external world. In other words, intelligence occurs within a context and, as I'll claim later on, intelligent behavior cannot be understood outside that external context. Further, it is just as important to understand the relation of intelligence to the external world of the individual as it is to understand the relation of intelligence to the internal world of the individual.

The third part of the theory relates intelligence not only to the internal and external world but also to one's level of experience in a given kind of task or situation. In other words, in the course of our lives, we often encounter tasks or situations that initially are novel. As time goes on, however, the novelty wears off and we find that we automatize, or make automatic, the performance of such tasks. Take, for example, reading. At the first- or second-grade level, reading is a

novel kind of cognitive task, and certain kinds of mental processes and components must be brought to bear. By the time one is in college, reading is no longer novel, and much of the processing has become automatic; in fact, in skilled readers, a lot of the word processing has to be automatic in order to leave resources available to the more complicated kinds of things, like understanding the main theme of the passage one is reading, or the plot. So the third part of the theory takes cognizance of one's experience with a task or situation. We believe that intelligence is best measured when the task or situation is relatively novel, or when it's in the process of becoming automatic. That's a brief overview of the theory.

To discuss the theory, I'll start with the so-called componential sub-theory, or the part of the theory that relates intelligence to the internal world of the individual. What I claim in this part of the theory is that the critical aspects of intellectual functioning for understanding intelligence are what I call meta components. (They're sometimes called executive processes.) These are the kinds of processes people use to plan what they are going to do, to monitor what they're doing, and later to evaluate the products of what they've done. In other words, the meta components are things like recognizing that a problem exists, defining the nature of the problem, choosing a set of mental processes for solving the problem, choosing a strategy into which you can combine those processes, allocating processing resources, and so on. My research and that of others suggest that these kinds of meta components seem to be essential to intellectual functioning. To the extent that one gets the so-called G or general factor, out of intelligence tests, it appears to be due at least in part to the shared nature of these meta components across tasks. In other words, on all of the various kinds of tasks one might encounter on I.Q. or other tests, these meta components are involved. It may sound that this view is straightforward and reflects the views of everyone, and I hope that will someday be true: but that is not now the case. There's quite a bit of disagreement among

investigators of intelligence as to just what intellectual functions are primary to intelligence. So, what I'd like to do is take an example of the conflict and disagreement that's going on and show what the various views are, and why I think that the meta componential view is correct. What I would like to do is to take one of these meta components -- namely, the allocation of processing resources -- and discuss it in more detail with relation to speed of processing.

It's a very common notion in this culture and some others as well, that to be smart is to be fast. So, for example, if you just ask people at a train station or a supermarket what they mean by intelligence, you'll get responses such as "reads quickly, talks quickly, thinks quickly, acts quickly," indicating that speed seems to be an integral part of their conception of intelligence. Indeed, when we say someone is quick, we usually mean that they're intelligent. Now that is people on the street. and you might wonder whether that would be the case with so-called experts in the field of intelligence. So what we did was to ask experts in the field and it turned out that it came up pretty much the same way -- that they also emphasize speed. In fact, you don't have to ask the experts; you can look at their theories. For example, I mentioned Jensen's choice reaction task, where you have your finger on a button and you have to press a light as soon as it turns on. The idea is that the faster you are, the more intelligent you are and, indeed, Jensen believes that intelligence is related to speed of neural connections. There is also the paradigm used by Earl Hunt, which concerns itself with the speed with which you can compare two letters. Hunt's calculation takes the time it takes you to say a capital A and a small a are identical in name, and subtracts from that the time it takes you to say whether they're physically identical, in order to get what he believes is a measure of the speed with which you can access lexical or verbal information in long-term memory. There are a number of other paradigms of intelligence which all boil down to the idea that to be fast is to be smart.

For fairness and equal time, I should mention that there is also a theory of intelligence which values being slow. This theory goes back at least to Thurstone who, in a little-known but important 1924 book, The Nature of Intelligence, suggested that a critical aspect of intelligence is the ability to withhold an instinctive response. In other words, when you're about to react in a way that's instinctive and typical and common, you can withhold that response and reflect as to whether that's the best response.

My own view is different from both of these. I hold that what's important in intelligence is not just speed or slowness, but knowing how to allocate your time. A smart person can be either fast or slow, but the critical thing is knowing when to be which. I'd like to give you a few examples of some research findings that would seem to support that theory. One example is a study we did on very complex kinds of reasoning. The purpose of this study was to isolate two meta components of reasoning, which we called "global planning" and "local planning." Global planning is the kind of planning you do that applies to a set of problems as a whole. If you're given a set of math problems or a set of reading problems or whatever, there are some things you can do in advance that apply to all of those problems. Others apply only to single problems, and the time spent on that kind of planning we refer to as local planning. The critical result was that we found that the more intelligent people (as measured by inductive reasoning ability) tended to spend relatively more time on global planning and relatively less time on local planning. In other words, it wasn't just that they were faster or that they were slower, but rather that they were better in allocating their time. They tended to spend more time up front preparing for the set of tasks as a whole, so that they would be better able to do each of the individual subtasks within the set. Other people have had similar findings. For example, researchers studying expert versus novice physics problem solvers have found that the experts spend relatively more time up front on global planning and relatively less time on local planning.

A similar finding came out of another study we did on reasoning, looking at the time one spent on various simple performance components of intelligence, for example, when one solves an analogy. Let's take the analogy of a lawyer is to a client as a doctor is to a patient. In such a task, it's necessary to retrieve attributes from memory in order to infer the relationship of the lawyer and client; then you have to map the higher order relation that relates the first half of the analogy to the second, and finally you have to apply that relation in order to decide that "patient" is a good completion. Well, we studied those kinds of components and what we found in adults is that if you look at some kind of global reasoning measure, the criterion or I.Q., the more intelligent adults tend to be faster on most of the operations, but that they are relatively slower on encoding. In other words, they spend relatively more time up front in getting a fix on exactly the terms of the analogy, and less time operating on those terms. That's what happened to me when I first came to Yale and set up my book shelf. Wanting to get my office set up, what I did initially was just to put the books on the shelf in no particular order. The problem was that whenever I wanted to find a book, I had to go through scores of books to find the one I wanted. I finally realized that the system was very inefficient, and I took the time to encode or alphabetize the books, so that subsequently I could operate more quickly on those encodings and find the books more quickly. Unfortunately, I haven't been very good at keeping the system, but the point is that the additional time spent at encoding pays off in terms of operating on those codes.

Another example is from a study we did on reading. Almost everybody, students and teachers alike, have much more to read than they can possibly find the time for. I find in my job, and you may well find in yours, that if I were to read everything I'm supposed to read with the same high degree of care, I'd never have time for anything else. Students first entering college often find that the reading load so increases that somehow they're going to have to figure out a way of allocating

their time. So, we decided to look at how people allocate their time. The way we did this was to give college students four sets of reading passages. They had a fixed amount of time in which to read those four passages. But one of them they were to read for gist, another for main ideas, another for detail, and another for inferences. We told the students which passages to read for which purposes, but we did not tell them how to allocate their time among passages, nor did we tell them in what order to read the passages. Those things were up to them. What we found is that the better readers were better time allocators. They tended to spend relatively longer on the more difficult passages, and relatively less time on the easier reading passages. In other words, they showed a greater variance in the amount of time they allocated to each reading passage, whereas the less able readers spent more nearly equal amounts of time on the various passages, regardless of the purpose for which they were reading. So, from each of these examples, what seems to be important in intelligence is not just speed or not just being slow, but rather knowing how to allocate one's time so as to be fast when necessary and slow when necessary.

I'd like to turn now to a second issue related to meta components, and that is what I call knowledge acquisition components. What is the role of knowledge versus process in intelligence? During the 1960's, it became a popular view that we need to understand intelligence primarily in terms of processes; that we had spent too much time looking at products, and we needed to understand how these products came to be. During the late 1970's, a different view came to predominate in psychology. That view held that what is really important is the knowledge base -- that somehow processes were not telling us enough about intelligence, and we needed to look at knowledge. One of the main findings that led to this was the study done by William Chase and Herbert Simon at Carnegie Mellon comparing expert versus novice chess players. When they began the study they expected to find that the difference was one of processing -- that the expert chess player either used different processes or executed the processes faster than the novice. But that didn't hold up. About all

they could find was that the experts drew upon a much wider knowledge base than did the novices, and that differences in knowledge base seemed to be accounting for differences in chess playing. Since then, that same finding has been repeated in a number of different domains, both in games like "G" and also in different subject-matter areas, such as physics and reading. The other point that I would like to make is that if you look at single test correlations with I.Q. -- in other words, you take each of the individual subtests of an I.Q. test and look at the correlations with total score -- you find that the single test that best predicts overall I.Q. is vocabulary. That kind of finding used to be embarrassing because vocabulary doesn't seem to be so much a test of process as a test of knowledge, but the finding is consistent with the knowledge-based view.

Our view is that of course knowledge is important, but if you were to look only at knowledge, you would never understand how differences in knowledge came to be. For example, let's go back to the chess playing. There are a number of players who have played equal numbers of hours, but some of those will become grand masters and some of them will just remain duffers. Presumably, there are people who have played as many hours of chess as Bobby Fisher or Boris Spassky, but who never became expert at chess. What is it that distinguishes the people who become experts from those who don't? We have tried to understand and measure the components of knowledge acquisition, which contribute to later individual differences in knowledge.

To examine this question, we have looked at people's learning of vocabulary through context. The underlying idea is that individual differences in vocabulary can be traced to individual differences in people's abilities to acquire knowledge from context. What we want to do is come up with some kind of theory on the basis of those individual differences. Let me give you an example. This is a fragment of a story which was used to measure vocabulary acquisition.

Two well-dressed people, one a tired woman of middle years and the other a tense young man, sat around a fire where the common meal was almost ready. The mother, Tanith, peered at her son through the oam of the bubbling stew. It had been a long time since his last ceillidh and Tobar had changed greatly. Where once he had seemed all legs and clumsy joints, he now was well formed and in control of his body.

The task of the student is to define the unknown words, which in this case would be oam and ceillidh. We gave high school students a series of passages like this one containing unknown words, and asked them to do the best they could in defining those unknown words. They are actually low-frequency words in the English language. Our theory as to how people do this task consists of three parts. The first part specifies knowledge acquisition components or processes. In other words, what are the processes that a person uses to figure out what the words mean? We find that there are three critical processes, which we call selective encoding, selective combination, and selective comparison. Selective encoding is figuring out what information in the passage is relevant to determining the meaning of the unknown word. It is, in other words, distinguishing relevant from irrelevant information in the passage. For example, in the passage I gave you, it is relevant that the oam came from a bubbling stew, but much of the other information is irrelevant. Selective combination is combining the relevant information in a way so as to create a positive structure, or a definition for that word. Selective comparison is relating the new information about the words to old information that already is stored in memory. So that's one part of the theory.

The second part of the theory is a contextual key that people use to figure out these meanings. In other words, these processes have to be applied to something. The kinds of cues used are things like spatial cues: where does the thing take place or where is it?; temporal cues: when does it happen?; class membership cues: did you learn anything

about the class of which the concept is a member?; equality cues: things like synonyms; and so on. So these textual cues are the second part, and the third part is what we call mediating variables. These are things that affect how well you can apply the processes to the textual cues. For example, if a cue occurs in close proximity to the unknown word, it's easier to apply that cue than if it's distant from the word. Another example is whether the cue occurs before or after the unknown word in the passage. Generally, it's easier to use cues that come before. We tested this theory for vocabulary learning and found that it predicts the difficulties of these unknown words quite well. Moreover, scores on our test correlate about .6 to .7 with standard measures of vocabulary and reading comprehension, as well as verbal intelligence. Now we can understand the correlation of vocabulary to general intelligence in terms of these processes of incidentally acquiring knowledge from context.

Another important part of the theory deals with the role of novelty and of automatization in intelligence. It's not enough just to talk about components. Suppose you're in a restaurant and you're trying to decide what kind of meal to have; whether you'll want dessert later, so maybe you should eat lighter now; whether you want an appetizer; and so on. You have to apply the performance components in implementing your decision. If it's a French menu, you might even have to apply the knowledge acquisition component. A task like deciding on a meal may be chock full of components, but it certainly wouldn't seem to be a very good basis for understanding or measuring individual differences in intelligence. The reason we point to that is that it's in the wrong region of the continuum of experience for testing intelligence. A better region would be measurement in a task when it's either relatively novel or in the process of becoming commonplace. I say "relatively novel" because you wouldn't, for example, want to give calculus problems to a five-year old and consider it a good measure because it's novel. Rather, you would want to use something relatively novel but not totally outside the person's experience.

We've measured the ability to deal with novelty in a couple ways. One is a sort of science fiction task, so let me give you some background. Think of precious stones. We usually think of emeralds as being green and sapphires as being blue, but it's not clear that they must be. For example, it's possible that emeralds might be grue -- that is, blue until the year 2000 and green thereafter. Regardless of whether or not there is any possibility of those things, what we presented people in this test with was altered states of the world. A second scenario is about another planet, Kyron, where there are four kinds of people; examples of which are plan people, who are born young and die old; and balt people, who are born old and die young. And then there is a scenario about still another planet, where substances are either liquid north of the equator and liquid south of the equator, solid north and solid south, liquid south of the equator but solid north of the equator, or solid south of the equator but liquid north of the equator. The students participating in these experiments had to learn how to reason in these rather odd, complex, and new kinds of situations. Our test was designed to decompose the student's reasoning into the elementary processes they used to solve the problems. The most interesting finding was that some of those components are related to dealing with novelty. So, for example, one of those would be transferring from one's original conceptual systems to the novel conceptual system -- for instance, from green/blue to grue/bleen. Some components were more mundane things like reading answers, reading words, and so on, but the critical finding was that it was the components dealing with novelty that tended to show the greatest relationship to one's ability to reason inferentially. In other words, what seemed to be important in higher-order reasoning ability is not just overall performance of specific tasks, but rather the ability to deal with novelty.

The second kind of problem that we study is the so-called insight problem. These problems are the kinds of things we often see in books like Games for the Super Intelligent. For example, one of these is,

"If you have black socks and brown socks in your drawer mixed in the ratio of 4 to 5, how many socks will you have to take out to make sure of having a pair of socks the same color?" Or another example is, "Water lilies double in area every twenty-four hours. In the beginning of the summer there is one water lily on a lake. It takes sixty days for the lake to become covered with water lilies. On what day is the lake half covered?" (Just for your information, the answer to the first problem is 3 and the answer to the second problem is 59.) These problems were constructed to measure three kinds of insights, which relate to the three knowledge acquisition components I discussed before. So, what are those three kinds of insights? The three are what we call, again, selective encoding, selective combination, and selective comparison. The idea is this: in selective encoding, one must distinguish relevant from irrelevant information. To take a famous example of this, consider Sir Alexander Fleming's discovery of penicillin. He was growing a bacterial culture in a petri dish, and the culture was spoiled by a mold. What was originally designed to be an experiment for one purpose had actually become an experiment of quite a different type. Fleming found that the mold was anti-bacterial, and in fact, it would be anti-biotic -- penicillin. That is an example of a selective encoding insight. In the socks problem, the information about the ratio of 4 to 5 is irrelevant to solving the problem. It's absolutely irrelevant information. The less able problem solvers tend to dwell on that irrelevant information in trying to solve the problem. The second kind of insight is an insight of selective combination, which is putting together in a novel way the information you need to solve a problem insightfully. A famous example of that would be Darwin's formulation of the theory of evolution. Darwin came up with a theory; but the facts necessary to constructing the theory had been around for a long time. What was new was his seeing how those facts could be combined. The third kind of insight, selective comparison, is relating new information to old information in a novel way. A striking example of that is Kekule's discovery of the structure of the benzene ring. They say that Kekule had been seeking the structure of this ring, and he had a dream about a snake that danced around and eventually bit its tail. And when

he woke up he realized that the structure of a snake dancing around and biting its tail was the structure of benzene.

We wanted to measure these three kinds of insights, although on a much lower level than these discoveries. We used problems such as the ones I mentioned and what we found is that we could separate the three kinds of insights. When we did the study with gifted and non-gifted fourth through sixth graders, we found that what seemed to distinguish the problem solving of the gifted from that of the non-gifted was their ability to solve and to perform these kinds of insights. When you cued the students, when you told them what the insight was, it greatly helped the performance of the non-gifted, but had no effect on the gifted, because they already had those insights. Again, the ability to deal with novelty, in this case through insight, seems to be a critical factor in intelligence.

I guess I will pass over automatization pretty quickly because we're running out of time, but what I would like to point out is how I think these concepts are important for understanding so-called culture fairness in I.Q. testing. The idea usually is that somehow you can measure cultural fairness by finding whether groups differ in their absolute levels of performance. What's been found in reviews of the literature is that on their face, tests seem not to be particularly biased. They don't mis-predict the performance of various groups. I would argue that this kind of analysis usually doesn't take into account the issues of novelty and automatization. In other words, it may well be that the processes and strategies used by members of different groups to solve these problems are essentially the same. But even if this is true, the problems themselves may differ drastically in the degree to which they're either novel or automatized for different groups of people. Take, for example, abstract reasoning problems. The original idea was that those would provide a more culture-fair measure than the traditional verbal problems, but what turned out is that, in fact, they showed bigger differences in performance across groups. It now appears that the reason

is that those problems were even more novel or non-entrenched to the members of other cultures than were the verbal problems. In other words, the whole business of trying to solve that kind of problem was totally foreign to them and often they didn't even see why you'd try to do that in the first place. Those who were acclimated to the U.S. test taking culture, on the other hand, might not even have to read the instructions for the problem: seeing the problem might be sufficient to cue them in to exactly what they needed to do, so that for them, the problems were not so novel but rather quite automatized.

I'd like to move on to the third and concluding part of this theory, and that is the contextual part of the theory. Here, there are three "macroprocesses" important to intelligence. They are adaptation to the environment, selection of an environment, and shaping of an environment. Let's start with the concept of adaptation. In contextual definitions of intelligence, intelligence is considered to be a function of adaptation to your environment. The importance of this can be seen as well anecdotally as in research. For example, Seymour Sarason of Yale tells the story of how when he took his first job, which was at a training school for the retarded, he arrived to find that the people he was to test were not there. What had happened was that in the school for the retarded, the people who were confined had planned and executed a successful escape, so he had nothing to do for a while. Eventually, the students, or inmates (whatever your prefer), were rounded up and they were brought back (I guess they weren't that smart) and at that point Sarason tested them. He found that most of them couldn't even solve the first problem on the Porteus Maze test. Clearly, there must be something more to intelligence than what the Porteus Maze test measured, since these people were at least smart enough to plan and for a while successfully execute this escape.

Another example of this is in the book, The Cloak of Confidence, which discusses what happens to retarded individuals when they're let

out of institutions. One of the examples in the book is about individuals who can't tell time, and one of the strategies they use is to wear a broken watch. On the street they look at their watch and say, "Oh, excuse me. I see my watch is broken. Can you tell me what time it is?" Now, clearly the fact that they can't tell time indicates that there's something missing intellectually; but the fact that they have the adaptive skill to wear the broken watch indicates that there must be something more again than what the traditional test would measure.

Adaptation, of course, can mean different things in different cultures, and very often we tend to be narrow in our conceptualization of just what is meant by adaptation. For example, in our culture, the smart thing to do in a sorting test is to sort taxonomically, so that if you're given a bunch of words like the names of fruits, names of animals, and names of vehicles, adults are expected to sort by higher-order categories. On the Wechsler and the Binet Intelligence tests, children are given more credit for high-order definitions than they are for functional definitions. So, if you define the word car as a vehicle of conveyance, you're given more credit than if you say it's something that uses gas or something that travels. The functional definitions get less credit. Well, in a cross-cultural study with the Kpelle, what Glick found is that when members of the Kpelle tribe were asked to sort, they invariably sorted functionally rather than taxonomically. By our standards, the people of the other culture would be considered less intelligent or developmentally less mature intellectually than people of our culture. But Glick persisted, and asked if these people could see any other way to sort. He tried to get them to do it taxonomically and couldn't. Finally, in desperation, he said, "Show me how you'd have sorted if you were a stupid person," and then they had no trouble at all sorting taxonomically. What they considered adaptive may have been quite different from what we consider adaptive, and clearly our test was not measuring their notions of adaptation or intelligence at all.

We've tried to study adaptation in the context of studying what we call tacit knowledge. The idea is that for success in the real world, what seems to matter is something more than what is taught in school. We interviewed high-level business executives and academic psychologists to ask them what they thought was critical to success in their occupation, and we found that they didn't think that what they learned in school was all that important. In fact, I find myself that almost everything I learned in graduate school (and I only got out eight to nine years ago) is pretty much irrelevant to what's being done today. It's not so much that it's wrong; it's just that the concerns of those in the field of educational psychology have changed. So what graduate student Rick Wagner and I attempted to do was measure "tacit knowledge", or the kind of knowledge that you pick up on a job but often is never explicitly verbalized. So, for example, we would give the business executives problems, some criteria that might be seen as leading to success in a business career, and ask them to rate on a scale of 1 to 9 the importance of each of these criteria. Another problem was that of a young business executive just starting out, who didn't have enough time to do everything he needed to do. So the test taker had to rate the priorities for doing each of the tasks confronting this executive. In another problem, we had the business executive giving advice to a younger business student. And we did similar kinds of things with the academic psychologist. What we found is that performance on their tacit knowledge test was correlated very highly -- at about the level of .4 -- with external criteria for success in those fields as in the case of the business executive's performance ratings, merit pay raises, and so on. In the case of the academic psychologist, it correlated with the number of publications, level of institution, and so on.

But performance wasn't correlated with traditional I.Q. In other words, there is something more than just I.Q. in that kind of adaptive success. But a theory of the intelligence of adaptation isn't enough because there are times when it is maladaptive to adapt. For example,

you may find that you're in a business of some kind and the values of management are repulsive to you. To take an extreme example, it would be hard to argue that being adaptive in Nazi Germany was necessarily the most intelligent thing. Or you may find that the situation or the environment you're in does not reflect your interests. You may find yourself in a career that bores you, or find yourself doing the kinds of things that just don't reflect where you are at all. Or you may find that your situation isn't such a good match for your ability. The point is that adapting isn't always the best thing to do. That truth leads to other alternatives. One might select a different environment, by deciding, "This is the wrong thing for me to do. I shouldn't be here and I'm getting out!" That could be in a job, in a school, in a marriage, or whatever. You essentially de-select an environment and re-select another.

But you wouldn't want people to select a new environment every time they failed to adapt to an old one. You wouldn't want, for example, that the first time a husband and wife have a quarrel that they decide to get a divorce. There has to be some other way of handling things. And that other way is the third macroprocess, shaping the environment. To shape the environment, you make the environment conform to you rather than you to the environment. If you look at outstanding individuals in almost any field, you find that they don't necessarily tend to be the ones with the extremely high I.Q.'s, or to be extremely bright in terms of the kind of things tests measure. Rather, they tend to be really good in one or two things. And what they have is an unusual ability to capitalize on whatever strengths they have, and to compensate for whatever weaknesses they have. In other words, whatever strengths they have they make the most of, and they make them important to what they do; whatever weaknesses they have, they make unimportant either by delegating them or by doing the job in a way that does not require those skills. For example, there doesn't seem to be any one research style that works, but rather different things work for different researchers. The same is true for teaching. What works for these people depends on the patterns of abilities a person brings to a task. What that means is that at least from the

standpoint of a contextual subtheory, intelligence isn't even quite the same thing for different people. Rather, it depends largely on not only what skills people have but whether they can make the most of those patterns of skills. These three steps, then -- adaptation, selection and changing -- relate intelligence to the external world.

I'd like now to draw this to a close. My major point is this: Intelligence tests probably do measure intelligence, but only a theory-limited aspect of it. What they're probably best at measuring are the so-called performance components of intelligence like the inference, mapping and application. They tend not to be very good at measuring the aspects of novelty and automatization, and they say practically nothing at all about a person's ability to adjust to real-world context. So that to the extent that we need to think about broadening our notions of intelligence and its measurement, I think the direction in which we need to move is toward better measuring those aspects that are not now measured by intelligence tests, namely, novelty, automatization, and fitting into context. The last point I'd like to make -- and I think it's important -- pertaining to what I see as a predictor criterion confusion that has become rampant not only in the teaching profession but among psychologists who study intelligence. The idea originally was to use intelligence tests to predict other kinds of performance. The I.Q. test score was thought to be a useful way of summarizing (in a rather crude manner) how a person might do in performances that counted -- in the case of Binet, academically. But what seems to have happened is that for many people the predictor and criterion have become reversed so that the tests have become even more important than the criteria that they were originally supposed to predict. A particularly bizarre but not uncommon example of this is the case of a teachers' college in Mississippi that required for admission the Miller Analogy test, which is an advanced test for graduate admission. This college required a score of 25 out of 100 for admission to the program. And that's sort of odd because 25, it turns out, is a chance score. They had a person who had a below-25 score who

they admitted because of other strong credentials, and this teacher proceeded to do extremely well in the program. The student would have graduated with honors except that the college was unwilling to grant a diploma until the person retook the test and got a score of at least 25. Happily, she did retake it, got a 26, and got her diploma. We may think that kind of thing is limited to Mississippi, but that's not true because I've heard the same story in many instances. Indeed, I cited a similar example earlier about the woman who wasn't admitted to the graduate program. In countless cases like that, the test becomes more important than the criteria it is designed to predict. In this particular case, the school should have known from the letters of recommendation that the woman was doing very well in research, which is, after all, what graduate school is about. But it wasn't enough. No matter how exact-sounding test scores may be -- and there is a certain comfort in having an I.Q. of 108 or an SAT score of 570 -- the important thing is not how accurate they are, but how valid they are. Intelligence tests as they now exist measure accurately only for some people some of the time, and in order to improve on that record, we'll have to broaden our conception of intelligence. The purpose of my talk today has been to suggest some ways in which we might do this. Thank you.

GETTING STEERAGE ON THE '80's

November 17, 1983

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GETTING STEERAGE ON THE '80's

by Harold Hodgkinson

One of the areas we want to look at is the remarkable increased amount of spending that businesses are expending on educating their own work force.

I have spent the last 20 years of my life in management, mostly in non-profits. As a matter of fact, none of my organizations have made much money. We have managed to clear things okay, but when I was with the Department of Education we had one staff meeting ... You have to remember that the year before I took over, the Senate vote on the budget for the Department of Education was zero. I have the only direct experience with zero-based budgeting in the federal government.

But that one staff meeting was on a Monday at 7:30 a.m. (which was the only time we could get together). I asked the staff to diagram the way the department really works. They came up with a hodgepodge of circles and squiggles. I have shown the diagram to AT&T executives, people at Digital and 3M and they say, "Yep, that's us."

Also at the Department of Education, I learned early that if you are a new administrator, the first thing you do is reorganize everything because that shows you are a real leader. I thought that was a particularly American trait, but I found an ancient quotation from the Roman Empire: "We trained very hard but it seems that every time we're beginning to come up with the teams, we would be reorganized."

*These excerpts from Dr. Hodgkinson's speech were transcribed from a tape-recording made at the City Club on the evening of Nov. 17, 1983.

I was to learn later in life that we tend to meet any new situation by reorganizing. What a wonderful method it would be for creating the delusion of progress while actually producing confusion, inefficiency and demoralization.

These problems with organizations are in no way new. The only thing new about it is that we now call it a science ... a science that substitutes regulation for good management.

We do have some unique problems in education; I think those in business are more aware of the nature of these problems than most people in education. It is the interface coordination between elementary and secondary, between public and private, between K-12 and higher education and between all those forces in the business world. Businesses are very large providers of education to their own workers; so are the military and others.

Another in education is credibility with the public, especially with state legislatures. I had the opportunity to speak to the Midwest Governors' Association recently. I talked with the governors about their role as they see the future of education in their states. I was amazed to find that every governor is indeed informed and involved. The Governor of Michigan made a moving presentation about their efforts to get a volunteer service corps going in that state to get some people off the unemployment role into doing something useful. Every governor had an education program that he did not need to talk to an aide about in terms of getting it straight. They had it right on top of their heads. It was very important to them.

I think we have about two years before the education agenda moves out front and center. During that two-year period, there will be a great deal of change that will happen at the local and state levels ... and that is where the change should happen. I do not believe

the change in policy should come from Washington. I think that Washington plays a supportive role, but the change is really important at the local and state levels.

We are beginning to develop some new support sources from new alliances the public schools are making with businesses and communities. I was present in one high school a few months ago which had started an alumnae association. All the graduates of this high school paid \$15 to this high school and started an alumnae association. They have generated \$220,000 in the revenue which will be put in an endowment fund for that public school. Ten years ago this would be unheard of. Who started that? Some businessmen who said there's nothing wrong about being a non-profit alumnae association. Every college in the country has it ... why not a public school? It is that kind of thinking which has really changed the way in which corporations can help education because we not only need the money, we need the ideas, the kind of innovation that comes largely from those folks.

I had the very fortunate privilege of being at a cocktail party with many foundation executives and some higher education presidents. One president of a distinguished college, who had just received a million dollars from a foundation, went over to the foundation executive and put his arm around this guy's shoulder and said: "With your money and our brains we are an unbeatable team." You just don't say that anymore. The notion that we have all the brains in education ... that, if people would just give us the money we could change the world ... is just not working. What foundations are saying is: "Change the world a little bit first and then come back to us and we will talk to you."

We also have in education this terrible problem of the roller coaster. In the '50's, it was equality. Everybody forgot everything else. In the '60's, it was innovation and everybody forgot everything else. In the '70's, it was relevance and everybody forgot everything else. And now it is excellence and everybody has forgotten equity and

equality and innovation and all those programs that were vital in the '60's. We tend to have a lot of trouble focusing on two things at once. One we can do, but two ... but name me a state that has focused on excellence and access at the same time.

We are now in a period that is supposed to be characterized by a lot of criticism about public schools. This criticism sounds familiar, so I went back to my library last week and I dug this up some critics from the past who have said the same things:

- Teachers' colleges are just awful, they say ... This started in 1925.
- There is not enough money to run schools.
- Permissiveness is random ... Permissiveness ... this is an agency of the Communist Party. There is a subversive element to that whole thing. Permissiveness leads to very dangerous kinds of alternatives.
- There isn't enough homework.
- European systems are better: if only American schools were more like the British. (If you have ever been to France or talked to an ambassador in the French cabinet .. all of them had to go through it ... before they could ever qualify ... it takes them three years to get into a high school ... and then look at the way the French make decisions.)
- The school day is too short.
- The school year is too long.
- There's not enough hard stuff like math and science ... if it is poorly taught that is all the better ... that means you should suffer. (If you see a bunch of kids having a good time in math class it is obvious they aren't learning. In literature that's okay, but not in math. Math is supposed to be hard and that means suffering.)

We will now have 23 national commission reports on the condition of American public schools. In December 1983, we could raise some question as to how many reports do we need. Especially given the facts that these reports consistently ignore elementary school, that they say nothing about higher education, nothing about the education of the handicapped, little about education for the gifted, almost nothing about minorities in America, little about the problems of American big city school systems ... those issues will be almost entirely ignored by these reports.

This is a time of great social criticism. I want to ask some questions about why. In preparation for some I came across this little diagram as what is happening with the medical practice. If that looks familiar to you it should because it is a response to some of the ... the independent practitioner in California in medicine is dead. That is, California has moved to large collective bidders against present provider contracts. If you have the contract from TRW, your hospital wants to win that contract. If you're a surgeon on that hospital staff, fine; if not, forget it.

The point is that we have so much trouble delivering services across education and other areas. The delivery of education needs to be very drastically reconsidered because of the fact that the environment in which it works is no longer the same as the environment in which it was hatched. So that is one way to think about the difficulty we are having. It puts the problem in a larger context than we normally think about it. We also have to face the fact that the financial recession which occurs every 30-40 years brings a wave of disillusionment ... we can't do anything right; we may as well just forget it; everything will sort of go away. Indeed I am reminded of the tombstone in Laramie, Wyoming that carries the inscription: "SEE I TOLD YOU I WAS SICK".

Basically, that is the way we worked between 1967 and 1972. It has nothing much to do with economy. It does have much to do with inflationary rates, however, because people were beginning to say in 1967: "We can no longer guarantee that my children will have a better life than I do because of the fact that my money is not appreciating in value ... put your money in a bank during that period. Inflationary rates are so high that you need ... that is if you are smart you don't save, if you were smart you borrowed. Because somebody else's money is inflated, not yours. That was a funny period.

I am happy to say that we have come out of that recession in about 1978. That was the first year that Americans reached increased faith in social institutions, increased happiness in life. It may be your 13th marriage but you're finally getting the hang of it. It was nothing in the economy that said that is what people should do. What else happened in 1978? If you have faith in the future and you look forward for tomorrow you are more likely to have children than if you didn't ... that is one reason why public schools have an increase in elementary age school children right now. So this change is not so much the public but people's expectations. The economy is in shambles but the culture is bursting with vitality. It does seem today that we have a whole lot of aspirations we can't fulfill economically. We really have conquered some illiteracy in America. In 1980, there were 20 million American illiterates ... a national tragedy. How many were there in 1960? Out of the total population now a small percentage is illiterate, i.e., we are making a little progress.

GETTING STEERAGE ON THE 1980s
(WHAT ISSUES WILL EMERGE IN U.S. CONSCIOUSNESS?)

I. EMERGENT VALUES

- A. END OF PSYCHIC RECESSION
- B. INTEGRATION OF THREE VALUE SYSTEMS
- C. NEW RULES FOR ADULTS
- D. MARKET DISAGGREGATION

II. DEMOGRAPHIC CHANGES

- A. THE "TWO NATIONS" HYPOTHESIS
- B. DIFFERENTIAL FERTILITY
- C. SINGLE-PARENT KIDS
- D. DEPENDENCY RATIOS -- AFDC TO AFDE?

III. THE WORK FORCE

- A. SHIFT TO SERVICE ECONOMY
- B. WOMEN IN MANAGEMENT
- C. HIGH TECH WINNERS, HEAVY INDUSTRY LOSERS
- D. EDUCATION IN INDUSTRY -- NEW ALLIANCES?

IV. EDUCATION'S RESPONSE

- A. NEW EMPHASIS ON RESOURCE RAISING, ALONG WITH
FUND RAISING
- B. DISCOVERY OF HRD BY EDUCATORS
- C. NEW EFFORTS AT DEVELOPING PRODUCTIVITY
(EVERYONE'S DOING QUALITY CIRCLES!)
- D. INCREASING PROBLEM OF MORALE, RIFs, ETC
- E. THE MINI-COMPUTER AND 1990
- F. IMPROVED MANAGEMENT IN EDUCATIONAL INSTITUTIONS

HOW ABOUT YOU?

... NEW RULES: I ...

IN THE 1950's AND THE 1960's, THE MEDIA TOLD US WE WERE IN A
CULTURAL REVOLUTION. IMPACT ON ADULTS LIVES? LITTLE.

. . .

IN 1980's, THE MEDIA SAYS A RETURN TO NORMALCY. BUT MOST ADULTS
ARE NOW SUFFERING THROUGH WRENCHING PERSONAL CHANGES.

- A. DEEP SENSE OF PERSONAL LOSS. (WE ARE ALL VICTIMS.)
- B. REINTEGRATION OF LIVES, GOOD NEW LEARNING BY END
OF 1980's.

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*** NEW RULES: II ***

** VALUE EVOLUTION:

I. DEPRESSION VALUES

HOLDING ON - SECURITY - PROTECTION

II. INSTRUMENTAL - "ME GENERATION"

SELF-CENTERED (INDULGENCE)

WILL I BE ABLE TO MAKE ENOUGH \$\$?

WILL I BE SUCCESSFUL?

WILL MY KIDS DO BETTER?

III. EXPRESSIVE - "SACRED"

SELF-FULFILLMENT (CREATIVITY, LEISURE, AUTONOMY, CHOICE,
T L C, ACTIVITY, CHOICE, STIMULATION)

HOW CAN I FULFILL MYSELF?

HOW CAN I GROW AND DEVELOP?

HOW CAN I PREVENT INFLATION FROM TAKING AWAY THE GAINS I'VE
MADE AND THE CHANCE TO LIVE THE GOOD LIFE?

MORE CHOICES, BUT NO DECISION RULES.

(GUIDEBOOKS)

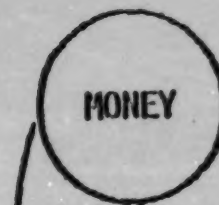
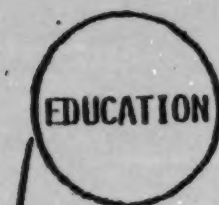
"AN INCREASINGLY SOPHISTICATED, BROADLY EDUCATED,
SELF-DIRECTED ADULT POPULATION FINDS ITSELF MANAGED
AND SERVICED BY LARGE-SCALE PUBLIC AND PRIVATE
INSTITUTIONS WHICH, BY THEIR NATURE, MUST STANDARDIZE
AND UNIVERSALIZE THEIR OPERATIONS AND OUTPUTS FOR
EFFICIENCY AND MANAGEABILITY."

(DAVID SNYDER, ASTD REPORT, JUNE 12, 1981)

THE MISMATCH IS BETWEEN SOCIETY'S DESIRES AND ITS
INSTITUTION'S CAPABILITY, AND INCREASES DISSATISFACTION
WITH LARGE INSTITUTIONS.

*** MARKET DISAGGREGATION ***

FROM:



TO:

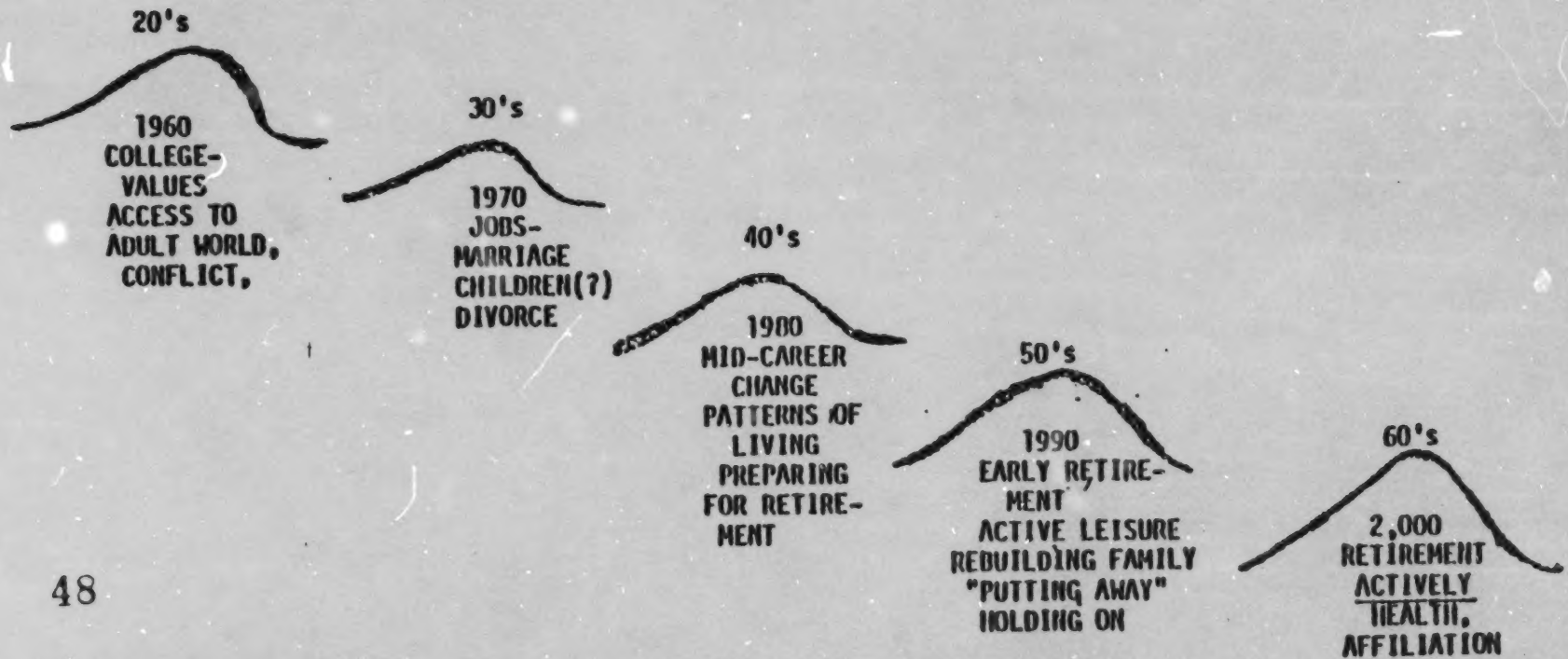
COLLEGE
BUSINESS
GOVERNMENT
MILITARY
UNIONS
CIVIC GROUPS

BANKS
SEARS (#1)
IIFC
MONEY MARKET
BARTER

UNIVERSITY
BUSINESS
PRIVATE R&D
MILITARY
GOVERNMENT

HOSPITALS
IMO's
FITNESS CENTERS
HOSPICES
YMCA's
BUSINESSES

*** AGE OF BABY BOOM ***
AND
KEY ISSUES FOR EACH DECADE



A BROADER LOOK

CORPORATIONS --

1. XEROX TRAINING CENTER
2. SCOTT FORESMAN'S LIFELONG LEARNING DIVISION
(BASIC SKILLS TEXTS FOR ADULTS)
3. DANA CORPORATION AND DANA UNIVERSITY
4. TWA FLIGHT TRAINING CENTER - KANSAS CITY

GOVERNMENT --

1. FEDERAL EXECUTIVE INSTITUTE (FEI)
MANAGEMENT TRAINING & SES
2. USDA "GRADUATE SCHOOL"
3. NATIONAL SOCIETY FOR TRAINING & DEVELOPMENT
(TRAINING AGENCY FOR CITY WORKERS)
4. DETROIT PUBLIC SCHOOLS - MANAGEMENT ACADEMY

PRIVATE NON-PROFIT PROVIDERS - TRAINING --

1. AMERICAN MANAGEMENT ASSOCIATIONS
(MANAGEMENT KNOWLEDGE)
2. NATIONAL TRAINING LABORATORIES
(INTERPERSONAL SKILLS IN MANAGEMENT)
3. FLAGSHIP UNIVERSITIES IN EACH STATE
4. AMERICAN SOCIETY FOR TRAINING & DEVELOPMENT
5. ASSOCIATION OF SCIENCE & TECHNOLOGY CENTERS -

ATARI !
TEXAS INSTRUMENTS !

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HAROLD L. HODGKINSON

... THE EXCHANGE GAME ...

WE HAVE:

BUILDINGS

FACULTY

COURSES

LIBRARIES

YOU NEED:

YOU HAVE:

ACCREDITATION

CREDITS AND CEU'S

TESTING CENTERS

REMEDIATION

MANAGEMENT SKILLS

STUDENTS

COUNSELING SKILLS

MONEY

SKILLED EMPLOYEES

MORALE RETENTION

JOB ANALYSIS

SKILLS TRAINING

WE NEED:

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*** EDUCATION AT AT&T ***

- EMPLOYS ALMOST ONE MILLION WORKERS
- INVESTS \$700 MILLION ON EDUCATIONAL PROGRAMS
(MIT BUDGET = \$222 MILLION)
- 2,000 PH.D.s WORK THERE, MOSTLY AT BELL LABS.
(MIT EMPLOYS ABOUT 900 PH.D.s.) NOBEL PRIZE IN
PHYSICS SHARED BY TWO BELL LABS SCIENTISTS THIS
YEAR.
- HIRES THOUSANDS OF TEACHERS, USES HUNDREDS OF
(THEIR OWN) FACILITIES.
- THEY DO NOT HIRE OUT THEIR PROGRAMS TO COLLEGES AND
UNIVERSITIES... DEGREES ARE LESS IMPORTANT FOR
PROMOTION AT AT&T.

CHANGE, JANUARY 1979, 26-35.

UPDATE: IN 1981, AT&T SPENT \$1.7 BILLION ON EDUCATION/
TRAINING. NSF WILL OPEN BASIC RESEARCH FACILITIES
TO RESEARCHERS FROM INDUSTRY (1981)

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*** LINKAGE TRENDS IN 1982 ***

1. 30 MASTERS DEGREE PROGRAMS IN HUMAN RESOURCE DEVELOPMENT
2. NORTHEAST ILLINOIS' INTERNESHIIPS IN NON-SCHOOL SETTINGS
(FIPSE)
3. CERTIFIED CONSULTANTS INTERNATIONAL
(LICENSING TRAINERS, CONSULTANTS)
4. ASSOCIATION OF FITNESS DIRECTORS IN BUSINESS & INDUSTRY
(FORMER PHYSICAL EDUCATION PROFESSORS)
5. IT'S YOUR BUSINESS
(LEAGUE FOR INNOVATION, PHOENIX, 1981)
6. BUSINESS & HIGHER EDUCATION: TOWARD NEW ALLIANCES
(SAN FRANCISCO, JOSSEY-BASS PUBLISHERS
NEW DIRECTIONS #13, SEPTEMBER 1981)

... NEW ALLIANCES OUTLINE ...

1. WHY NOW?
2. WHO IS PLAYING THE GAME?
3. WHAT ARE THE RULES?
4. WHEN SHOULD I:
 - A. GET INTO THE GAME.
 - B. GET OUT OF THE GAME.

(AT RENO, THE GAME WILL GO
ON EVEN AFTER YOU LEAVE!)

... NEW ALLIANCES -- WHY NOW? ...

1. DECLINE IN 18- TO 24-YEAR-OLD COHORT.
 - A. BUDGET DECLINES.
 - B. END OF ERA OF YOUTH-ORIENTED SOCIAL CHANGE.
2. ALL SOCIAL INSTITUTIONS HAVE CREDIBILITY PROBLEMS.
 - A. DECLINE IN INDUSTRIAL PRODUCTIVITY.
 - B. DECLINE IN VOLUNTARY PARTICIPATION.
 - C. ATTACK ON 501-C-3 STATUS.
3. INFLATION IS COMMON ENEMY.
 - A. RELATED TO DECLINE IN "PROTESTANT ETHIC" AND TO 2. ABOVE.
4. DECLINE IN KNOWLEDGE MONOPOLY OF COLLEGES AND UNIVERSITIES.
 - A. INCREASE IN EDUCATIONAL SYSTEMS IN OTHER SECTORS (INDUSTRY, MILITARY).
5. LOW PROFILE TIME, DESIRE TO SHARE AND SERVE ADULT NEEDS, TRAVEL AND COMMUNICATION EASY, DATA ACCESSIBLE.
6. NEW THEORIES (PICTURES IN OUR HEADS).
 - A. HUMAN RESOURCE DEVELOPMENT, LIFE QUALITY.
 - B. ADULT DEVELOPMENTAL STAGES.

*** DECISION RULES FOR COLLABORATION ***

1. WHEN YOU CAN'T COMPETE & WIN (ZERO-SUM GAME).
2. WHEN EACH GROUP GAINS MORE BY COLLABORATION
(EXPANDABLE POT).
3. WHEN BOTH AGREE ON RELATIVE RISK FOR EACH.
4. COMMON PURPOSE AT SOME WORKING LEVEL.
5. STAFF SUPPORT AT RELEVANT LEVELS IN EACH GROUP
FOR THE OTHER.
6. WHEN "COIN OF THE REALM" HAS BEEN ESTABLISHED.
(ONE APPLE IS WORTH TWO ORANGES.)
7. WHEN CRITERIA THAT WILL END THE ACTIVITY ARE
ESTABLISHED IN ADVANCE (MORE THAN SOME
ACADEMICS CAN STAND!).
8. REMEMBER THE RENO METAPHOR: THE GAME GOES ON
AFTER A GIVEN PLAYER LEAVES.

POTENTIAL COLLABORATORS

1. MILITARY

Literacy Training
Skill Development
Task Analysis
Re-Learning, Continuing Ed.
Internal Promotion

2. PROFESSIONAL ASSOCIATIONS

Continuing Education
Flexibility
Individualized Teaching
Internal Promotion

3. INDUSTRY

Job Assessment
Programmed Learning
Counseling
Use of Theory (X & Y)
Internal Promotion

4. MUSEUMS

Instructional Sequence
Multi-Media
Simulations-Games
Learner Involvement
No Promotion

5. PROPRIETARY INSTITUTIONS

Marketing
Apprentice Model
Links with Local Business
Job Placement
Vocational Counseling
Internal Promotion

6. HEALTH

Competence Based
Clinical + Interno Settings
Links with Practice
Internal Promotion

HAROLD L. HODGKINSON

*** FROM FUND RAISING TO
RESOURCE RAISING ***

1. MONEY IS ONLY ONE RESOURCE -- ITS VALUE IS ALWAYS SHIFTING.
2. HUMAN RESOURCES CAN "GROW" FAR MORE RAPIDLY THAN MONEY.
3. YOUR UNUSED CAPACITY -- BUILDINGS, PEOPLE, EQUIPMENT AND SERVICES -- IS YOUR MAJOR RESOURCE FOR RESOURCE RAISING.
4. THE QUALITY OF YOUR NETWORKS DETERMINES THE QUALITY OF YOUR RESOURCE RAISING PROGRAM.

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*** RESOURCES ***

1. FISCAL (MANY GOOD INNOVATIONS ARE CHEAP!)
2. HUMAN (TIME IS OUR MOST PRECIOUS RESOURCE.)
3. PSYCHIC (REWARDS & STATUS, INCENTIVES, LOWERING THREAT LEVELS.)
4. ENVIRONMENTAL (WHY EMULATION SELDOM WORKS.)

QUESTION: HOW CAN WE MAXIMIZE OUR "RETURN" ON
OUR USE OF EACH OF THESE RESOURCES?

*** COMPARED TO WESTERN EUROPEANS ***
AND THE JAPANESE, AMERICANS ARE:

1. MOST WILLING TO FIGHT FOR THEIR COUNTRY.
2. MOST PROUD OF THEIR NATIONAL IDENTITY.
3. MOST LIKELY TO TAKE PRIDE IN THEIR WORK.
4. MOST DEEPLY RELIGIOUS.

"PROUD TO BE A CITIZEN" - UNITED STATES = 80%
IRELAND = 60%
GREAT BRITAIN = 55%
JAPAN = 30%
WEST GERMANY = 21%

"I AM PROUD OF MY WORK" - UNITED STATES = 84%
JAPAN = 37%
WEST GERMANY = 15%
FRANCE = 13%

(CARA - GALLUP COORDINATED - 1982)

THE ADULT LEARNING MARKET, 1979:

154 MILLION ADULTS
116 MILLION INDEPENDENT LEARNERS
98 MILLION - SIZE OF LABOR FORCE
75 MILLION - ADULT WOMEN
65 MILLION - LACK BASIC SKILLS
60 MILLION - WANT TO TAKE A COURSE
40 MILLION - IN CAREER TRANSITION
23 MILLION - ORGANIZED LABOR
20 MILLION LACK COMPETENCY
19 MILLION - CREDIT PLUS NON-CREDIT
14.5 MILLION - COLLEGE DROP-OUTS
12 MILLION - ORGANIZED PROFESSIONS
6 MILLION - UNEMPLOYED YOUTH
3 MILLION - IN MILITARY SERVICE

(FUTURE DIRECTIONS FOR A LEARNING SOCIETY; 1980.)

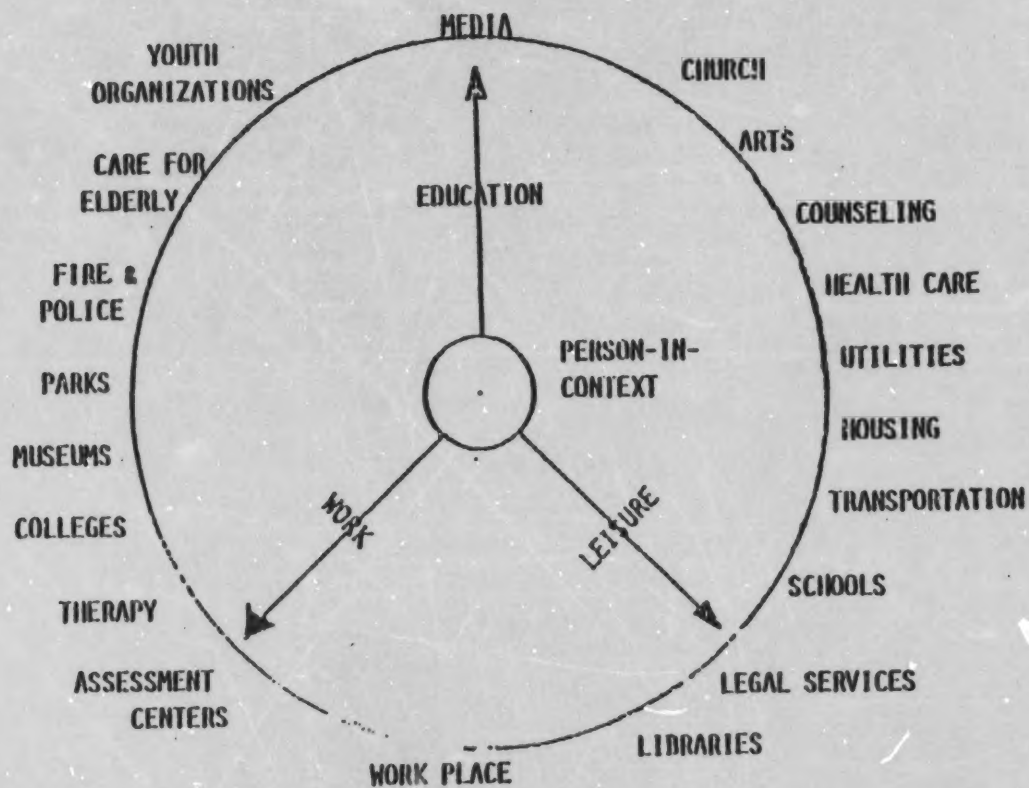
HAROLD L. HODGKINSON

WHO IS LEARNING WHAT? WHERE?

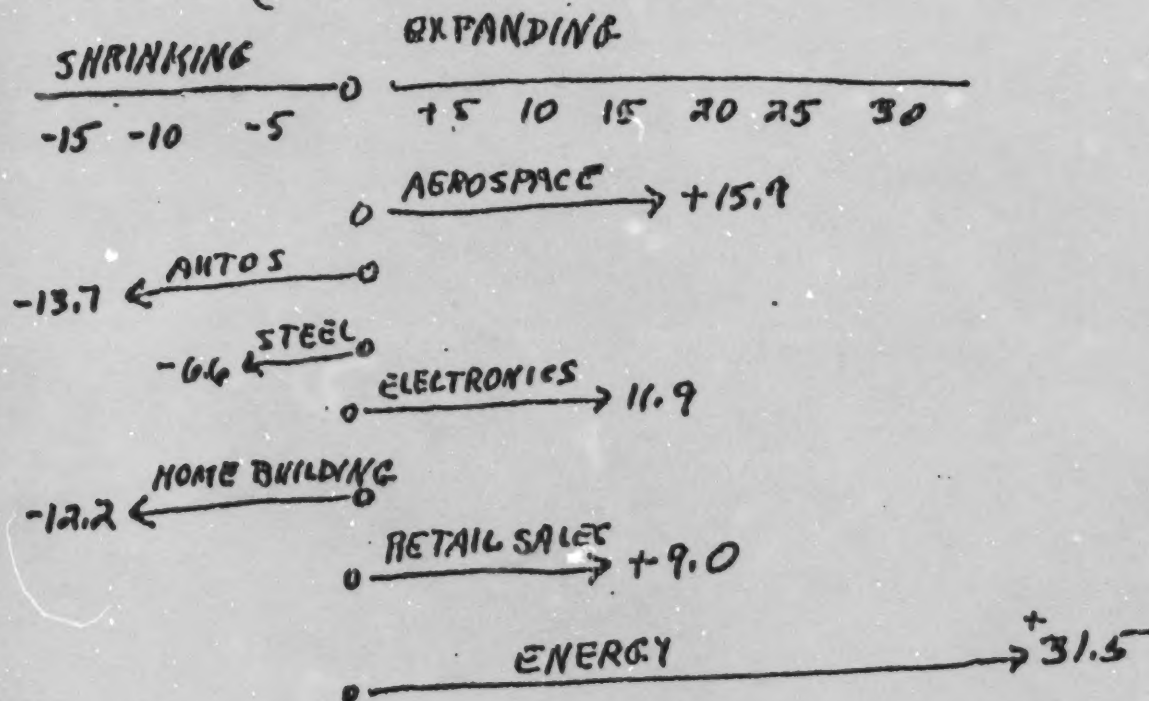
AGRICULTURAL EXTENSION	12.0 MILLION
COMMUNITY ORGANIZATIONS	7.4 MILLION
BUSINESS AND INDUSTRY	5.8 MILLION
PROFESSIONAL ASSOCIATIONS	5.5 MILLION
PART-TIME COLLEGE	5.3 MILLION
CITY RECREATION	5.0 MILLION
CHURCHES, SYNAGOGUES	3.3 MILLION
COLLEGE AND UNIVERSITY EXTENSION	3.3 MILLION
GOVERNMENT SERVICES	3.1 MILLION
PUBLIC SCHOOL ADULT PROGRAMS	1.8 MILLION
FEDERAL MANPOWER PROGRAMS	1.7 MILLION
ARMED FORCES	1.5 MILLION
GRADUATE AND PROFESSIONAL	1.5 MILLION
TRADE UNIONS	.6 MILLION
COMMUNITY EDUCATION	.5 MILLION
FREE UNIVERSITIES	.2 MILLION
TOTAL	58.4 MILLION
IN COLLEGES	12.4 MILLION
OTHER SETTINGS	46.0 MILLION

*** INTEGRATION OF COMMUNITY SERVICES ***

(BASED ON OPEN ACCESS TO SERVICE CENTER "RING")



PERFORMANCE OF KEY INDUSTRIES (BY REVENUES, 1980) -



THE COMPUTER AS COACH:
APPLYING ARTIFICIAL INTELLIGENCE TO EDUCATION
November 18, 1983

Dr. John Gallagher
Director of Education Computing
FUQUA School of Business
Duke University

THE COMPUTER AS COACH

by

John Gallagher

I have been teaching instructional psychology, or instructional design, for some time and I very much buy into the models traditionally presented -- either Bloom's, Gagne's or other taxonomies. In other words, I believe that within any domain there are generally lower-level and higher-level kinds of learning, and that in order to achieve higher-order learning you must have a grasp of underlying principles. The other basic precept of this approach to instructional psychology is that within any domain -- in kindergarten it's dealing with shapes and colors, or in a graduate school of business it's dealing with marketing strategies -- it is possible to identify knowledge, comprehension, application, analysis, synthesis and evaluation types of outcomes within that context. For each one of these kinds of learning it is possible to describe the appropriate instructional technique to use. If we are trying to teach someone knowledge outcomes, we have instructional tools to do that and do it well. If we want to teach someone comprehension outcomes, we have tools for that: application, we have tools for that: analysis, we have tools and techniques for that. At about this point it begins to get a little weak.

The premise that I'm operating from is that we have a great deal of interest in and dedication to the idea of teaching higher-order problem-solving skills. For a long time schools have been accused of teaching rote kinds of materials and of graduating people who understand the basic information that they've been taught, but are unable to apply it in a creative, problem-solving mode. What I'm going to discuss today is a relatively new technology that has a lot of promise for developing theories of and approaches to the teaching of problem-solving skills.

What we do now is give people experience, give them background at all of these different levels and when we get up to the synthesis and problem-solving areas, we give students problems to solve. It's usually some kind of an essay or project. Then they solve the problem and we evaluate what they've done. We apparently believe that problem-solving skills are going to develop through the act of solving problems; that somehow, just through doing more of it, people will become better problem solvers. So we give people lots of well-structured problems to solve. That's the current technique.

What I'm presenting today is a new field in computing -- just 15 to 20 years old -- known as artificial intelligence, or A.I. Some people describe artificial intelligence as anything that is on the forefront of what we can currently program a machine to do. If we can't quite do it yet, then it's artificial intelligence. A slightly more rigorous definition of A.I. calls it programming to emulate human cognitive processes -- generally, reasoning processes. In other words, artificial intelligence attempts to create machines which do things that we believe require human intelligence -- complex tasks, complex problem-solving outside the domain of things we have done in the past with machines. Artificial intelligence is an approach to designing computer programs that has caught the fancy of people in computer science, people in cognitive psychology, and a few people in instructional design. I will be talking about the implications of this kind of programming for instruction because there is a very strong link between the two fields. We are on the verge of seeing some exciting educational applications of the developments that are taking place in this field.

There are two different groups that operate in the field of artificial intelligence. One of them is interested in producing products. They want to expand computer applications so that computers can do things they couldn't do before. Another group of people -- generally in the cognitive sciences -- believe that by creating computer programs which

can perform higher-order problem-solving kinds of tasks, we will better understand the nature of the tasks themselves. They are interested in using this as a technique for studying how people solve problems. It's that second goal that I think is most important here. The idea is that we are going to write computer programs which are models of the way people solve complex problems in difficult areas; and that by doing so, we will come to understand better how that problem-solving and reasoning takes place.

Many of the artificial intelligence programs written to date take the form of what's called an "expert system" -- that is, a computer program which is an expert in a specific domain. I'll give you an example of the differences between traditional computing and what we call expert systems, or artificial intelligence computing. Most of us have heard of computer programs that play chess. About 20 years ago, people began to devote themselves to the problem of creating computer programs that could play chess well enough to play at a master level. Early attempts to do that used the following kind of procedure: When it was the computer's turn to make a chess move, the computer attempted to look several moves ahead by determining the possible moves that it could make now. For each move it could make now, the computer had to determine all the possible moves its opponent could make in response. And given the possible moves by which its opponent could respond, the computer had to determine what subsequent moves it could then make. Well if you play chess, you know the possible number of moves you could make at one time can be very large. If you compute the possible moves an opponent could make in response to every one of these, and then determine all the possible moves you can make to each of those, it becomes a permutation problem of considerable magnitude. Programmers found that when they programmed computers to look four or five moves ahead, even high-speed computers took up to four hours to decide what move to make next. Even then, chess masters beat those programs hands down, time after time after time. That traditional programming approach is what we call brute-force computing. Since we have all this memory, all this computing power, then

we'll find the answer if we just look at every possible combination. But you can't beat people that way because that isn't the way people play chess.

Expert chess players see patterns on the board and they have a set of general rules or strategies which they apply to solve this problem of winning the game. Cognitive psychologists began to develop the notion that people solve problems by applying a set of heuristics to a problem. They use rules of thumb, general approaches; they're able to see the board in terms of strength and weakness. They use simple rules -- such as, maximize strength in a specific area of the board to keep from being vulnerable to attack -- to play very sophisticated games of chess. So they began to program computers using these models. Programmers worked with chess experts to uncover how they solve these problems, and through that understanding they were able to write a different kind of computer program. Those computer programs beat chess masters. That's an artificial intelligence approach, because it tries to emulate the problem-solving approaches that people naturally take. They got those approaches by working with an expert who is capable of reasoning at a very high level within that domain.

Trying to get the expert to explain the problem-solving process can be a very difficult task, since they're no longer aware of it. We sometimes say they're operating on intuition. Well, it's not intuition. I think it's a sophisticated method of pattern matching that they're able to devise after a great deal of experience, and they no longer are conscious of how they perform. I think this is why we get people who are experts in their field who can't teach. In some cases, we end up with a kind of mentor system where we have students who are ready to learn something sophisticated hang around the expert and watch what they do. If they are good at asking questions and pulling that information out, they may learn something. People develop expertise in some fields by an osmosis process.

This new approach to modeling expert behavior has led to a very different view of how experts do things. People who build these systems start by creating a knowledge base because it's clear that experts are well grounded in a large amount of factual information. Factual information about the chess pieces, for instance, or the dimensions of the board, the rules of play that govern which pieces you can move at which time and where you can move them, all is stored in the computer. Also stored explicitly in the program are rules for operating on the knowledge base. There are rules for inference, and there are rules for deductions used to generate more knowledge from the knowledge base. In other words, the computer can operate on the given facts to create more information which may be needed to solve a problem. So there's a knowledge base and there are rules for operation on that knowledge base.

One of the conclusions to come out of a lot of this research is that when human beings solve problems they establish a goal, and then to achieve that goal, they develop a subgoal. My goal in playing chess is to achieve checkmate, but that goal is too broad to guide my immediate behavior. More immediately, I must decide what it is I'm going to do next. So I establish a subgoal, which might be to establish some dominant area on the board. In order to achieve that subgoal I've got to move some pieces; so there is an additional subgoal by which I determine which piece to move. We are constantly establishing subgoals in solving problems. Depending on the situation, we have different very specific goals that guide our behavior. Further, we look at the information in front of us in a different way depending on what goal we have at the moment.

There have to be some rules for generating the goals and subgoals we use in solving a problem. These are very sophisticated problem-solving techniques that we call heuristics. You can imagine what a difficult task it is to create such a system. The methodology of getting these systems built is a very difficult one; but when it's finished, you have

a knowledge base and problem-solving activities that are explicit. They are in a computer program, unlike the knowledge of a human expert which is implicit in their behavior and may not be accessible. In artificial intelligence you have it modeled, and you can test the model. The nice thing about these programs is that while the computer is solving problems you can ask it to explain what it's doing and why. Because the rules are explicit, the computer can explain its actions as it solves the problems. The computer can tell you, for instance, "this is what I'm trying now and it isn't working, so I'm going to go back and look at it differently." "Now I'm going to think about it this way, and this is what I'm going to do next." Or, "this is the information I need to determine if this is a good route to take." These programs can be written so the computer can articulate the process it's going through while that process is occurring.

I want to give you an idea of what some of these systems are and then get on to the educational implications of all this. Expert systems exhibit some kind of higher-order problem-solving or reasoning behavior within a specific domain. For example, Caduceus is a computer program that does very complex medical diagnosis. It's the second generation of a program that was originally called Internist. This program has exhibited expert behavior to the degree that it can make complex medical diagnoses better than 85% of graduates of the major medical schools in this country. Not as well; better. Imagine having a program on a microcomputer in a suitcase of a group of emergency medical people who go out and diagnose problems better than 85% of graduates of the major medical schools in the United States. With a floppy disk! It's been around for years, and it's being used.

PUFF is a program for the diagnosis of pulmonary function disease that has been used for a number of years, I believe in San Francisco. Doctors use it because it works. Not only does it diagnose things, but it also tells you how it arrived at that conclusion so you can determine

whether it appears reasonable or not. You can ask it questions. "Why did you do that? What if the person had had a temperature of 104°, what would you have concluded or asked?" You can treat it like a colleague.

There's a program called Prospector which does mineral inspecting by analyzing ore samples. It has a geological map stored inside of it which tells the mining company where to go, what analyses should be done, and where minerals are most likely to be found. Last year Prospector found a mineral deposit that is supposedly worth about 100 million dollars. The exploration company was delighted they had invested the dime developing the Prospector program.

Digital Equipment Corporation has a new program they call R-1 which designs computers to meet customers' specifications. It takes the place of a very sophisticated design engineer in electronics. If you tell the computer you need a system with particular characteristics, the machine asks questions and designs complex electronic devices to meet those specifications.

I want to point out that each of these programs has a financial payoff. That's why we're going to see these things. They've been in the laboratories of universities for 15 years and they occasionally get newspaper coverage because people find it amusing that a computer knows how to generate recipes. Now people are finding out there's a lot of money in this. I spent the last few months in a business school and we just held a three-day conference on artificial intelligence and business-making strategies. They want to know how to make marketing decisions with a computer. Companies are tired of having somebody in the business for 15 years -- long enough to develop some expertise -- get tired and either slow down or move on. They want to capture some of that expertise in a computer program so they can quickly train new people. One reason this field is growing is that the implications of this for financial reward are becoming clear.

What about the educational value of all this? How does this fit into instructional design, and where does it fit in with the goals of a conference like this one? To discuss that I'm going to show you an expert system for teaching. This system is an expert like the others I've discussed, but it has added to it a knowledge base and a set of rules for tutoring. It is an expert instructional system for teaching someone about problem-solving. It probably is better, or has the potential to be better, than working with a human expert because it not only knows how to solve problems, but it can also tell you about it; it can monitor your behavior while you're solving a problem, it can tell you when your reasoning is inconsistent with the facts, and it can point out faults in that reasoning process.

I want to get back to the instructional design issue, the matter of teaching problem-solving. I'm going to share with you a dialogue between a student and this program. The people who designed this are not teachers, by the way, but artificial intelligence folks. (Overhead slide) What you have to know is that this is an electronic circuit. I don't know what any of these symbols mean and they aren't important. What I want you to consider are the quality and nature of the dialogue between the student and the machine when the student tries to troubleshoot the problem with this circuit.

Inside the computer is a model of a circuit, and the computer goes in and randomly picks a component and "breaks" it. The student's job is to find out what's wrong and to repair the circuit. It's a diagnosis problem. It's the same as a patient going to the doctor with certain symptoms. What tests should be run? How can a diagnosis be made? But this one is an engineering problem, and the student's job is to take measurements, get information, and try to diagnose the circuit board. What the student does is ask questions, such as, "What is the voltage at this point?" "What is the capacitance at this point?" And the machine gives the student the requested information as the student tries to solve the problem.

The program is called SOPHIE -- Sophisticated Instruction in Electronics -- and it is a reactive learning environment. The piece of equipment you are studying is a regulative power supply. The computer asks the student, "Would you like to start with a faulted instrument which needs fixing?", and the student responds, "Yes." The computer tells the student what the circuit's present control settings are. The student is given some information about how this instrument is set up and is told to locate and solve the problem.

The student types in "What is the output?" The machine responds that the output is 11.7 volts. "What is it in a working instrument?" "In a working circuit the output voltage is 19.9 volts." So the student has already started to ask some questions to get the necessary information to diagnose this problem. "What is the voltage between R8 and Q17?" Obviously the student has formed a hypothesis, and is beginning to ask more specific questions. The machine replies that the voltage at a specific point is 47.6 volts. "What is the BSE emitter of the voltage-limiting transistor?" The computer gives the student that piece of information. "What about for the current limiting transistor?" And the student gets the answer to that. "What should the base emitter be?" "In a working circuit the base emitter voltage of Q6 is .593." And then the student says, "Replace Q6." The student has formed and tested a hypothesis, and says that this component called Q6 is broken and should be replaced.

At this point the machine says, "I'm going to ask you some questions about how Q6 is faulty." The machine knows how to solve these problems; it knows the information the student has been given and what deductions can be made from that; and it knows whether the student's answer is correct or incorrect. Now it goes into the role of a tutor, and the conversation continues. "Are any junctions shorted?" it asks. And the student responds, "I don't know." "Are any terminals open?" "Yes." "Which terminal or terminals are open?" The student responds, "The base." But the computer replies, "Q6 is not faulted in that manner. Q6 is not replaced." In other words, the student is wrong. The student

now asks, "Is it possible that Q6 has an open base?" And the computer answers that that is possible, and continues. "When the settings were CC = 1, CR = High, Load = 20, VC = 1, VR = High, you observed that the output voltage was 11.7 volts. If Q6 had a fault mode EB/EC/BC = OP/OK/OP", in other words if it was broken the way the student thinks it's broken, "it would be 23.9 volts. In a working circuit it's 19.9 volts. What you hypothesized is inconsistent with the information that you've already been given." The computer goes on to tell the student what is inconsistent: "You observed that the base emitter voltage of Q6 was .349 volts. If Q6 had fault mode EB/EC/BC = OP/OK/OP, it would be .712. In a working circuit it would be .593. Your hypothesis does not explain any of the symptoms that you observed."

This is an instructional approach in teaching problem-solving we have not had available because we did not have the technology -- not technology in terms of hardware, but technology in terms of what is being called "knowledge engineering." By learning to design these kinds of systems, we come closer to understanding how problems in a given domain are solved. We have the ability to teach someone how to solve problems once we have that explicit information available to us. Students who are trained with this system have a much lower "mean time to repair". A student's average time to repair a broken instrument is significantly less after having gone through this kind of training, as opposed to traditional laboratory training in electronics troubleshooting.

The overlap of artificial intelligence and education is just at the edge right now, but I think that's going to be changing radically. Educators are getting interested in the idea of computer technology and they're beginning to ask whether there are ways to use these machines in the classroom in a unique way. Not just to do drill and practice or programmed instruction better. We can do that already. We can teach people association learning; we can teach people to memorize facts; we can teach people to analyze problems; we can do these things already. Is there anything unique this machine can do that can change the quali-

tative effect of classroom education? This is an area where I think it can.

Another important point is that this machine is teaching. There is a model in this program with a knowledge base and rules about how to tutor someone. When do you interrupt? When do you give a counter example? When do you give a hint? All that is explicitly programmed in the machine. If it doesn't seem to work, you can change the program. The SOPHIE program provides a way of stating a theory for tutoring, and of modifying it until it works. It provides the basis for developing instructional theory in the area of problem-solving. We are now able to teach problem-solving explicitly, rather than by example. This is an important breakthrough in education.

QUESTIONS AND ANSWERS

Q: How much effort is required to produce expert systems such as these you are discussing?

A:— The effort required to develop expert systems has been a function of time. They talk about person-years involved in developing these kinds of systems. The person-years required to produce programs such as these in 1965 was approximately 8 years of time. Now you're not going to get McGraw Hill to do that for your curriculum. That rate has been dropping and dropping as A.I. programming techniques have developed; but there's an analogy that no matter how many women you get together it still takes 9 months to make a baby. Well, it's the same sort of thing that no matter how many people work on it, there's still this development time that's required. It's generally wizards who have been trained at MIT or Yale or somewhere like that who go off into their labs and work for 2-3 years.

Last month the first piece of software was made available that people have been waiting for a very long time. That is a program that interacts with the experts. And through questioning them and going through the information extracted from the experts, the program builds the knowledge base and builds the rules for operating on that knowledge base. They built an expert system to build expert systems. If you're an expert in real estate, it can sit down with you and ask you questions and say, "Is this what you mean? Give me an example. This is the conclusion I would come to. Where am I inconsistent with you?" etc. And in a matter of -- now they're measuring it in hundreds of hours -- in very specific domains they can extract and build expert systems. So we're no longer talking about years in development time.

Q: Where in the learning/instruction literature do you find a basis for building the tutoring parts of these programs?

A: Where do you find parallels in learning theory? Discovery learning is about it and that is such a difficult area to research. I believe that this methodology will do a great deal to stimulate theory in this area. The manifestation of a theory in a computer model which can be tested and modified should prove to add rigor to a very complex field.

Q: What do you think of the argument that teaching programming to students will improve their problem-solving ability?

A: There is an argument that's been around for a long time and I've made it myself, that through writing programs people develop problem-solving techniques. They have to come into contact with their thought patterns and how they're solving the problem and put that in a program. The only thing I would add at this point is that if the objective is really to focus on their problem-solving behavior that you make that objective clear by saying, "I want you to write a program, but I also want you to write a 3 or 4 paragraph explanation of how you're approaching that problem and how you're solving it and how this computer program

manifests that." So that they explicitly think about those problem-solving techniques. You say, "That's the purpose of this -- it's for you to understand how you're solving the problem." I think that just letting it happen indirectly, as a result of just writing programs, it doesn't happen reliably.

Q: I am afraid of our increasing dependence upon machines and our tendency to consider them a human. Do you see a time when we don't talk with one another, but rather to machines?

A: I understand that. I don't really have a response for it to be honest. There's a lot of fear around the idea that the machine is becoming intelligent and what that means for interpersonal relations and I just have to rely on some kind of faith. I couldn't go through the day, I couldn't go through my life without having meaningful personal interaction and I can't imagine that simply because I don't need to talk to you to get information about how to fix an electronic circuit that I would stop talking to you. I would talk to you because I have basic human needs and we as people will get together and talk about this process that we go through because we're people and that's what we do. And that's how we learn. Expert systems are supplemental. This is supplemental to other kinds of learning; it's a tool or technique you plug into an instructional program and I don't see it as replacing that human interaction at all. I don't think it ever could. Maybe in science fiction terms but not realistically.

Q: How would you apply this in a classroom? Would you have kids interact with expert systems all day? What is the role of traditional classroom instruction?

A: We're right back to the old Bloom model that I started with. These things are hierarchical; you can't teach the synthesis kinds of skills, the problem-solving skills, until these other pieces are in place. My strong argument is that for knowledge and comprehension, drill and practice programs and programmed instruction can be used in a very efficient and effective way to bring that about. There's no problem.

Going into the application and analysis level, we're beginning to learn how to use simulations. Simulations are extremely powerful teaching tools. We're dealing with those middle levels of application and analysis and I think that the use of simulation in helping us do those kinds of things is a very important application of computers. But I was just particularly addressing the top end of this taxonomy today. Traditional and computer-based methods exist which are excellent for teaching the other levels.

Q: Doesn't all of this begin to raise more questions about how to teach problem-solving than it really answers?

A: It sure does. The whole idea of how -- when do you introduce this into someone's education? How much underlying information in problem-solving experience do they have to have in order to benefit from this? There are probably points where you could introduce this in someone's professional development where it would be counterproductive. Those are theoretical questions that we haven't asked yet because we haven't had to ask them. Now I think we're going to have to. So those will be the questions that will be of importance. These things I've described today are just shot from the hip; you know, let's try this. If a person seems to make a mistake, let's interrupt them and tell them -- that may or may not be the best way to use this information instructionally. It seems to work all right but I'm sure that as instructional psychologists begin to get hold of this that the educational implications will become much clearer. The developers of those expert systems have been computer scientists who are dabbling in the area of teaching.

Artificial Intelligence

WARNING!

THERE IS NO MEANINGFUL
DEFINITION OF THIS FIELD

- 1) Anything on the forefront of what we can program a machine to do.
- 2) Programming to Emulate Human Cognitive Processes
- Generally Reasoning

GOALS

- A) Expand the utility of Computer Applications
- B) To Better Understand How People Perform "higher-order" tasks.

Expert Systems: "Higher-Order,"
"Problem-Solving", "Reasoning" Behavior
within a Specific Domain

- Caduceus - Complex Medical
Diagnosis
- PUFF - Diagnosis of Pulmonary
Function Disease
- PROSPECTOR - Mineral Prospecting
- Electronic Design (RI)

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Expert Systems Are NOT Algorithms -
They emulate Human Problem Solving
Systems

- A) Knowledge BASE IN A SPECIFIC
Domain
- B) Rules for Operating on the
Knowledge Base
- C) "Goal + Subgoal" Directed
Rules for Problem Solving
(Heuristics)

Because Knowledge and Problem-
Solving Activities are Explicit,
Expert Systems can Explain
how they are dealing with Complex
Problems.

WELCOME TO SOPHIE, A REACTIVE LEARNING ENVIRONMENT. THE PIECE OF EQUIPMENT YOU ARE STUDYING IS A REGULATED POWER SUPPLY.² WOULD YOU LIKE TO START WITH A FAULTED INSTRUMENT WHICH NEEDS FIXING?
>>YES³

SOPHIE randomly selects a fault, inserts it into a model of the instrument and tells the student how the controls are set.

THE INSTRUMENT HAS A FAULT AND ITS PRESENT CONTROL SETTINGS ARE:

CC	1.0	CURRENT CONTROL
CR	HIGH	CURRENT RANGE SWITCH
LOAD	20	LOAD RESISTANCE IN OHMS
VC	1.0	VOLTAGE CONTROL
VR	HIGH	VOLTAGE RANGE SWITCH

It is assumed that the student has already had an introduction to the basic principles of the power supply so

the above comments are sufficient to characterize the controls.

**>>WHAT IS THE OUTPUT?
THE OUTPUT VOLTAGE IS 11.7 VOLTS.**

The student begins his troubleshooting by performing measurements in the faulted circuit. Notice that "the output" was disambiguated as the output voltage.

**>>WHAT IS IT IN A WORKING INSTRUMENT?
IN A WORKING CIRCUIT THE OUTPUT VOLTAGE
IS 19.9 VOLTS.**

In case the student does not know what the value of a measurement should have been, he can have any measurement repeated in a working instrument. Note the student's use of the pronoun "it" to refer to the previous measurement.

**>>WHAT IS THE VOLTAGE BETWEEN R3 AND
Q1?
THE VOLTAGE AT N1 IS 47.5 VOLTS.**

The student requests an internal measurement. Notice that even though the sentence form is "voltage between x and y", it really means "voltage at x with respect to ground." The output routines reduce the input to its simpler form (i.e., between x and y reduces to Node 1).

**>>WHAT IS THE BSE EMITTER VOLTAGE OF
THE VOLTAGE LIMITING TRANSISTOR?
-BASE
-TRANSISTOR
THE BASE EMITTER VOLTAGE OF Q5 IS -.037
MILLIVOLTS.**

The spelling corrector has detected and corrected two misspellings. The system must also know that Q5 is the voltage limiting transistor.

**>>WHAT ABOUT FOR THE CURRENT LIMITING
TRANSISTOR?**

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THE BASE EMITTER VOLTAGE OF Q6 IS .349 VOLTS.

The meaning of this question is completely dependent on the context established by the prior sentence. The system uses this context to determine that he is interested in not only voltage measurements but the voltage across a particular junction.

>>WHAT SHOULD IT BE?
IN A WORKING CIRCUIT THE BASE EMITTER
VOLTAGE OF Q6 IS .593 VOLTS.

Another way of requesting that the prior measurement be repeated in a working instrument, i.e., the meaning of "should" implies that a working instrument be used.

>>REPLACE Q6
I AM GOING TO ASK YOU SOME QUESTIONS
ABOUT HOW Q6 IS FAULTED.

The student believes he has discovered the problem and tries to fix it. Before a component is replaced, however, the system queries him as to how he thinks it is faulted. In the case of transistors (which have complex fault modes), if he gets at least something right, the system tells him what was actually wrong and replaces the broken transistor.

ARE ANY JUNCTIONS SHORTED?
>>I DON'T KNOW
ARE ANY TERMINALS OPEN?
>>YES
WHICH TERMINAL(S) ARE OPEN?
>>THE BASE
Q6 IS NOT FAULTED IN THAT MANNER. Q6 NOT
REPLACED.

After learning that Q6 does not have an open base, the student asks if this was at least reasonable hypothesis.

>>IS IT POSSIBLE THAT Q6 HAS AN OPEN
BASE?

Before the system's evaluation procedures can be applied to his idea or hypothesis, the hypothesis must be completely specified. To help the student out, the system suggests a plausible complete specification of it.

IS THE COMPLETE FAULT MODE EB/EC/BC =
OP/OK/OP WHAT YOU INTENDED?
>>SURE

The fault mode should be read as: the emitter base junction (EB) is open (OP), the emitter collector junction (EC) is okay (OK) and the base collector junction (BC) is open (OP).

WHEN THE SETTINGS WERE:
CC=1.0, CR=HIGH, LOAD=20, VC=1.0, VR=HIGH
THAT FAULT CONFLICTS WITH THE FOLLOWING
MEASUREMENT.
YOU OBSERVED THAT THE OUTPUT VOLTAGE
WAS 11.7 VOLTS.
IF Q6 HAD FAULT MODE EB/EC/BC = OP/OK/OP
IT WOULD BE 23.9 VOLTS.
IN A WORKING CIRCUIT IT IS 19.9 VOLTS.

In determining the logical consistency of his hypothesis with respect to the measurements he has already made, a glaring counterexample is discovered.

ALSO:
THAT FAULT CONFLICTS WITH THE FOLLOWING
MEASUREMENT.
YOU OBSERVED THAT THE BASE EMITTER
VOLTAGE OF Q6 WAS .349 VOLTS.
IF Q6 HAD FAULT MODE EB/EC/BC = OP/OK/OP
IT WOULD BE .712 VOLTS.
IN A WORKING CIRCUIT IT IS .593 VOLTS.

The system then points out a more subtle counterexample.

THAT FAULT DOES NOT EXPLAIN ANY OF THE
SYMPTOMS YOU OBSERVED BUT IT IS
CONSISTENT WITH THE VALUES FOR THE BASE

EMITTER VOLTAGE OF Q5 AND THE VOLTAGE
AT N1.

Finally the system tells him what is right or at least consistent with his hypothesis.

>>WHAT IS THE OUTPUT OF THE CONSTANT
CURRENT SOURCE?
THE OUTPUT OF THE CONSTANT CURRENT
SOURCE IS -.59 MILLIAMPS.

To understand this request the system must also know about the functional blocks of the instrument. Also note that the system had to determine that "output" in this context meant "output current" as opposed to "output voltage" as was meant in the first question of the protocol

>>V BETWEEN N4 AND N5
THE VOLTAGE BETWEEN N4 AND N5 IS 1.84
VOLTS.

Noun phrase utterances get interpreted as questions. "V" is an accepted abbreviation for voltage.

>>COULD THE PROBLEM BE THAT THE BASE
OF Q3 IS OPEN?

The student constructs another hypothesis

IS THE COMPLETE FAULT MODE EB/EC/BC .
OP/OK/OP WHAT YOU INTENDED?
>>YES
UNDER THE SETTINGS:
CC-1.0, CR-HIGH, LOAD-20, VC-1.0, VR-HIGH
THE FAULT WHICH YOU PROPOSED WILL
PROPAGATE.
LIKELY FAULTS WHICH MIGHT OCCUR ARE:
R22 OPEN
WOULD YOU LIKE ME TO CONTINUE TESTING
YOUR HYPOTHESIS IN A CIRCUIT IN WHICH-R22
IS OPEN ALSO?
>>NO

The hypothesis proposed by the student logically entails another component being blown. Before further evaluation of his hypothesis, the user is queried as to whether he realizes this entailment. If he does not, he is given the chance to have his hypothesis evaluated in a "ghost" world in which that component would not have blown.

WOULD YOU LIKE ME TO COMMENT ON YOUR
HYPOTHESIS AS IF NO OTHER PARTS HAD
BLOWN?

>>YES

WHEN THE SETTINGS WERE:

CC-1.0, CR-HIGH, LOAD-20, VC-1.0, VR-HIGH,
THAT FAULT WOULD HAVE CAUSED THE
FOLLOWING SYMPTOM.

YOU OBSERVED THAT THE VOLTAGE BETWEEN
N4 AND N5 WAS 1.64 VOLTS.

IF Q3 HAD FAULT MODE EB/EC/BC • OP/OK/OP
IT WOULD BE 31.3 VOLTS.

IN A WORKING CIRCUIT IT IS 1.7 VOLTS.

ALSO:

THAT FAULT CONFLICTS WITH THE FOLLOWING
MEASUREMENT.

YOU OBSERVED THAT THE OUTPUT VOLTAGE
WAS 11.7 VOLTS.

IF Q3 HAD FAULT MODE EB/EC/BC • OP/OK/OP
IT WOULD BE 1.19 VOLTS.

IN A WORKING CIRCUIT IT IS 19.9 VOLTS.

THAT FAULT DOES NOT EXPLAIN ANY OF THE
SYMPTOMS YOU OBSERVED BUT IT IS
CONSISTENT WITH THE VALUES FOR THE
OUTPUT CURRENT OF THE CONSTANT CURRENT
SOURCE, THE BASE EMITTER VOLTAGE OF Q5
AND THE VOLTAGE AT N1.

Again the student's hypothesis fails.

>>SAVE

CONTEXT SAVED, TO RETURN TO IT TYPE
'RESTORE'.

YOU NOW HAVE A WORKING INSTRUMENT
WITH WHICH TO EXPERIMENT.

The student has discovered more flaws in his understanding and is probably surprised by the high voltage between N4 and N5 that follows from his hypothesis (i.e., 31.3 volts). Wishing perhaps to explore what caused R22 to blow and what led to this unexpectedly high voltage he requests that the present troubleshooting context be saved (i.e., his fault and all his measurements which are the gist for the evaluation specialist). He can now perform any experiments he wishes.

>>WHAT IS THE CURRENT THRU R22 WHEN
IT IS SHORTED?
IF R22 WERE SHORTED UNDER THE PRESENT
SETTINGS, THE CURRENT THRU R22 WOULD BE
61 MILLIAMPS.
IN A WORKING CIRCUIT IT IS 1.8 MILLIAMPS.

This is an example of a hypothetical or conditional question. Note that "it" refers to R22 which is embedded in a noun phrase earlier in the same statement.

>>WHAT ARE THE SPECS OF R22?
THE SPECIFICATIONS OF R22 ARE:
VALUE - 510 OHMS
POWER/RATING - .5 WATTS

He now asks a factual question which simply gets looked up in the semantic net.

>>RESTORE
PREVIOUS SITUATION RESTORED.

He may have figured out why R22 blew when Q3 opened and now wishes to get back to the task of troubleshooting.

>>WHAT COULD BE WRONG?
HERE ARE SOME FAULTS WHICH EXPLAIN THE
MEASUREMENTS YOU OBSERVED:
THE BETA OF Q3 IS LOW
THE BETA OF Q4 IS LOW

OR R22 HAS THE WRONG RESISTANCE

He seems to have run out of ideas and requests some help. At this point the hypothesis generation "specialists" are invoked. These procedures examine all the measurements he has thus far made and then construct a collection of hypotheses which are logically consistent with the values of these measurements.

>>IS THE EMITTER CURRENT OF Q4
CORRECT?
THE EMITTER CURRENT OF Q4 IS -81
MILLIAMPS.
IN A WORKING CIRCUIT THE EMITTER CURRENT
OF Q4 IS -49 MILLIAMPS.
THAT VALUE SEEMS TO BE INCORRECT.

This question is in some sense a cheat. It really consists of two measurements. If SOPHIE were assigning costs to his measurements or questions he would be charged accordingly.

>>COULD R22 BE LOW?
IS IT OKAY IF I USE 25 OHMS FOR THE
RESISTANCE OF R22?
>>YES
THAT FAULT AGREES WITH ALL OF THE
MEASUREMENTS YOU HAVE MADE.

Finally he generates a reasonable hypothesis, but this does not mean that R22 is necessarily low! Just that R22 being low is consistent with what he should be able to determine from his measurements thus far.

>>WHAT IS THE RESISTANCE OF R22?
THE MEASURED RESISTANCE OF R22 IS 25
OHMS.
>>REPLACE R22
R22 REPLACED
NOW YOU SHOULD TAKE MEASUREMENTS TO
SEE IF THERE IS ANYTHING ELSE WRONG.

The system decides he must know what is wrong with R22 so it does not hassle him like it did when he asked for Q6 to be replaced.

>>NOW WHAT IS THE OUTPUT?
THE OUTPUT VOLTAGE IS 19.9 VOLTS.
>>WITH A 1000 OHM LOAD?
WITH THE LOAD NOW SET TO 1000
THE OUTPUT VOLTAGE IS 30 VOLTS.

He discovers that the unit is now functioning correctly. Note the ability of the system to handle rather extensive ellipses such as "with a 1000 ohm load".

>>WHAT WOULD HAPPEN IF R22 WERE
SHORTED?
IF R22 WERE SHORTED UNDER THE PRESENT
SETTINGS:
CC-1.0, CR-HIGH, LOAD-1000, VC-1.0, VR-HIGH
THERE WOULD BE NO CHANGE IN THE OUTPUT
VOLTAGE (I.E. 30 VOLTS).
HOWEVER UNDER THE SETTINGS:
CC-1.0, CR-HIGH, LOAD-10, VC-1.0, VR-LOW,
THE OUTPUT VOLTAGE WOULD BE .623 VOLTS.
IN A WORKING CIRCUIT IT IS 9.93 VOLTS.

A good example of what else is involved in handling hypothetical questions. Here the system first guesses that he is interested in output voltage since he didn't specify anything particular. Then it fails to find any change of the output voltage with the present load resistance. However, before it concludes that R22 has no effect it uses some other knowledge about the circuit to decide that a better test case or example would be to set the instrument up with a heavier load. Under this setting it does find a significant change.

>>GOODBYE

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Sophie has two "Expert" Components:

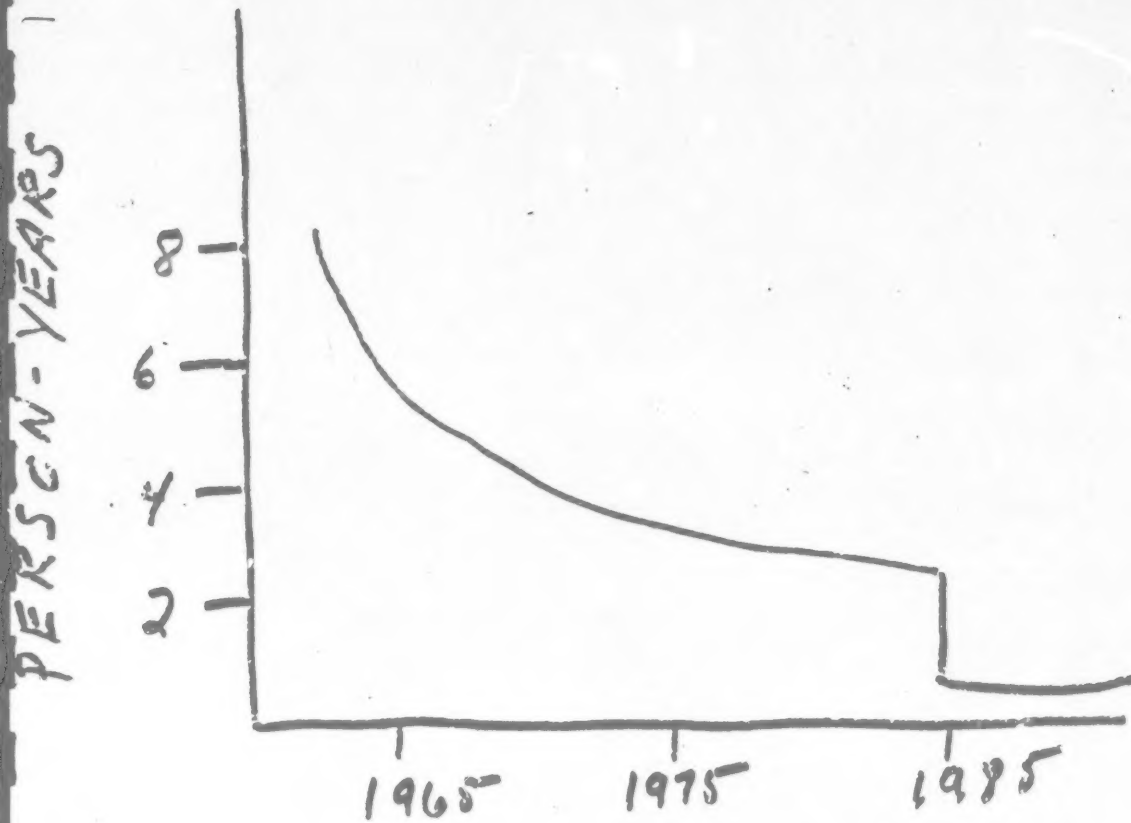
A) Electronic Fault Diagnosis

B) Tutoring

The Tutoring Component is a rule-and knowledge-based model of Teaching for Problem-Solving Skills.

It is testable + Modifiable

EFFORT REQUIRED TO DEVELOP EXPERT SYSTEMS OVER TIME



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Intelligent Tutoring Systems,
New York: Academic Press

HAYES-ROTH, F., Waterman, D. +
Lenat, B. (EDS.), 1983 BUILDING
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Addison-Wesley.

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EXCERPTS

FROM:

- Action Session Summaries
- Transcriptions from the Sharing Session, November 18, 1983
- Evaluations

EXCERPTS

From:

- Action Session Summaries
 - Transcriptions from the Sharing Session, November 18, 1983
 - Evaluations
-
- John Stafford, Superintendent of Orange Schools

What we get out of these conferences is that we are not doing enough fast enough ... and we are going to be pushing in some areas.

We have a main frame computer that has 24 parts in it ... and we have 24 microcomputers in a district for 1900 children. Our goal for September is to have three buildings each with a network classroom. We will have to give in-service credit to those teachers in those classrooms to prepare for their use of computers.

Numerous fringe issues come out of this conference that have caused us to do some thinking. One thing is to investigate interdisciplinary programs in the high school and get away from departmentalization. We are not sure that departmentalization will suffice in the society we are approaching.

In the content areas as we have them now, we are going to have to impose on all of them to do better in preparing young people with coping skills to handle this transition from what we are in to whatever we are going to. We want to be aware of the high-touch elements to deal with the high-tech elements.

We believe we need to look again at the mission of our schools. From the end of World War II, there have been some changes in the mission: the war itself, Sputnik, the vocational and special education

onthrasts ... and now it looks like we are being held responsible for the prosperousness of our country. And that certainly will change the mission!

To do all of this raises the question: how can we do these things in an evolutionary way rather than a revolutionary way? The longer we wait, the more we are going to be forced into a revolutionary way ... we are concerned about that. We will not have the people with us on the landing because they would not have been with us on the take-off ... so we need to look at that very carefully.

We are still concerned that, of all the things that have been presented during this last year, much of it falls within the range of psychological community ... and we are not getting enough services out of that group. We may put together a team of psychologists in our own community who could advise us about issues like how to deal with the single-parent family and the kind of preparations and anticipations we should have to deal with needs of those children.

• Jim Luengo, Chillicothe Schools

We think it is very important for us to go back to our district and begin to develop meaningful dialogue with some corporate people in middle and top management. We were very impressed with the Nov. 17th dinner meeting. It is stimulating that a CEO from one of Cleveland's largest businesses is interested in education. We are also impressed with the idea of sharing resources with industries. We have a large paper mill in our community ... and we should begin to tap that resource.

We think it is important to develop life-long learning skills for our students. At the last conference we learned that we are going to

have to educate people three times for three different skill areas in three different jobs. Today we learned that it is going to be five, not three.

We want to encourage our staff to become more active with computers. On the way here, we thought we had done a pretty good job. We had gone from one to 49 computers ... but we heard a lot more about computers this time, and we know we need to be more active in that area.

From Action Sessions:

- One district has a Futuristic Committee where teachers, principals, board members and community members attend conferences such as this so that they have an opportunity to interact with each other. They take the new knowledge back to the district to share with others and plan how to deal with the implications of it.
- We are going to explore opportunities for exchanges of teachers between school districts as well as exchanges with business people.
- The networking concept has much promise. One suggestion we have is that the conference experts we heard might become part of the network and continue to share new things with us. One specific example is Dr. Gallagher's idea that computer algebra will probably be developed very soon ... and we should like his opinion about which type of software would be particularly valid.
- We are going to begin looking at what kind of alliances will be helpful to us as educators as schools and society face the year 2000.
- We may not have a future in the education business if we don't improve the quality, efficiency and become excellent.

* This Action Session group identified areas of common concern, including the following:

- We are still dealing with an industrialization style or approach to learning.
 - How to respond to Dr. McLeod's request to provide the right environment to develop potential.
 - We need to restructure teaching styles.
 - Kids do not need to be given more information -- we should teach them instead how to deal with information.
 - Carmen Cancel's meaningful and insightful work in cultural differences should be used.
 - We need to consider an IEP type planning such as now used for G/T and Special Education for the middle group.
 - Every grade level should have a curriculum specialist who understands the child at that stage of development.
 - We have become more conscious of learning and teaching styles.
- * The ideas from these conferences must be used as a reference ... to refer to from time to time as we face problems that need solving.
- * We need to look for places to use artificial intelligence programs to release persons to work on other issues.
- * There should be more "interfacing" with industry ... not just regarding careers, but also on how to organize and how to instruct to complete a task.

- * How could we go about teaching pre-schoolers how to think?
- * What is the main goal of organizing pre-school education?
Is it convenience to parents, socialization or conformity?
- * Many children come to school with an inability to use language to express concepts. We need to model good language behavior and look at adapting language usage.
- * Teacher-training needs to be reconceptualized ... how can we expect teachers to teach thinking if they were never taught how to teach it?
- * Self-concept is an antecedent to learning. Avoid elitist approach by considering learning styles, strengths, weaknesses and by assisting the learners in arranging their potentials. Use testing, counseling, classroom learning -- a total school approach. Use Sternberg's Triarchical Model; Internal Mental process, External Mental Process (PACE).
- * We need to teach problem finding and problem solving.
- * Teacher improvement occurs most effectively as situations arise and through supervision that establishes goals with the teacher and follow-up.
- * Since vocabulary is the best single predictor of intelligence, we must be sure we teach it by methods that are useful to student development. We must also be watchful of vocabulary effects on our multi-cultural populations.
- * Link the schools with the external resources. Corporations can adopt a school. Corporate executives and educators could work together to plan.

- * Focus on teaching parenting skills within the school curriculum and to adults as they are becoming parents. Infant learning begins in the home, and children need to be taught to become effective parents
- * Use the model of the F.E.E. conferences, giving teachers an opportunity to meet and discuss learning in "buildings" groups.
- * Have conference experts send information to us as it becomes available. An example is Dr. Gallagher letting us know when a good expert system on algebra is available.

We like to attend the F.E.E. conferences because we get the kinds of information we really need and that is useful. We like the chance to get together with people from other parts of the state ... and we find that to be a good motivator for us at home. We also like the fact that everything about these conferences is "first-class".

APPENDIX

CLEVELAND HEIGHTS-UNIVERSITY HEIGHTS SCHOOLS

Widely acclaimed for its academic programs, Cleveland Heights-University Heights perennially places among the top ten districts and private schools in Ohio in the number of National Merit Scholarship semi-finalists. The district's music program is well known, and more than a dozen Heights High graduates are now with symphony orchestras. The district offers an integrated, structured program for gifted and talented students from pre-school through grade twelve.

The schools enjoy outstanding community support, with the second highest property tax rate in Cuyahoga County. The racial, ethnic and religious diversity of the district is emphasized in the high school's multi-cultural center, which brings in dignitaries, resource people and displays in an effort to promote understanding and appreciation of one another.

Other programs include an elementary "magnet" school featuring individualization with emphasis on math and another magnet featuring traditional education with emphasis on French, Spanish and computers; an alternative school program at the high school for students with "freer" learning styles; programs within the district and in cooperation with other districts for vocational education and education of the handicapped; a wide range of sports and extra-curricular activities; pre-school programs through the Community Service Department; extended kindergarten, an all-day program for the children of working parents; and a comprehensive adult education program.

The district serves University Heights, most of Cleveland Heights and a small portion of South Euclid; 1 high school (grades 10-12), 3 junior highs, 10 elementary schools; enrollment 8,500, modest decrease over next five years; 400 teachers; pupil-teacher ratio approximately 20 to 1; 72% of graduates go to college.

Cleveland State University

College of Education

CENTER FOR THE STUDY OF INDIVIDUAL DIFFERENCES IN
LEARNING AND INSTRUCTION

The Center for the Study of Individual Differences in Learning and Instruction was established in 1980 within the College of Education. It functions as a forum for bringing together College and University Faculty with interests in the cognitive, affective, social, and physical differences between learners that influence the nature and effectiveness of their educational experiences. Issues identified for emphasis may be based in a single area of study or may be interdisciplinary in character, may vary on the continuum of basic to applied research and may variously combine programmatic research, evaluative, and developmental emphases. A special focus is directed toward study of those problems characteristic of the urban environment. Proposal preparation this past year has involved comparative study of the consequences of stress among learning disabled, gifted, and typical children; the evaluation of gender and culture fairness in micro-computer educational software; implementation of the effective schools literature; and a computer camp for gifted and talented junior high school students.

The Center is a loosely coupled organization designed to provide leadership in the delivery of support services to faculty. The Center is not an administrative unit but carries out its activities within the existing departmental structure. Sponsored activities this year included a series of seminars in the new methodology of meta-analysis as well as a colloquia series featuring faculty research on such topics as feedback in counseling, learner performance across the life cycle, learning profiles of low birth weight children, and reader literary response patterns.

OHIO SITE, EDUCATION POLICY FELLOWSHIP PROGRAM
Institute for Educational Leadership

The Cleveland program is the first urban, non-capital EPFP site and is funded by the Cleveland and George Gund Foundations. The site was established in 1976 and is designed to strengthen educational leadership in local school districts, human services agencies, and institutions of higher education.

Twenty-two Fellows participate in the 1982-83 program and represent a broad spectrum of city, county and state agencies as well as private organizations. The list of sponsoring agencies is impressive: seven public school systems (Berea, Cleveland City, East Cleveland, Cleveland Heights-University Heights, Euclid, Nardon Hills, Vandalia-Butler), Cuyahoga Community College, Western Reserve Academy, Lorain County Community College, Case Western Reserve University School of Medicine, The Foundation Center, Federation for Community Planning, Office on School Monitoring, Ohio Department of Education, the U.S. Navy Finance Center, and the Cuyahoga County Board of Education.

The education component includes sessions on foundation support for education and educational change and on the policy process as viewed by advocacy groups, administrators, public servants and the business community. Other themes include issues of higher education design, school desegregation, women in leadership roles, delivery of human services and the politics of education.

Training activities include a site visit to Columbus to study the legislative process and the perspectives of legislators on education issues. In addition, EPFP hosts several seminars annually to provide the current Fellows with an opportunity to meet the Cleveland alumni/ae and to discuss policy issues with Cleveland sponsors.

The Cleveland site is affiliated with the Shaker Heights City School District. The Ohio site coordinator is Dr. Mark Freeman, Director of Research, Development and Evaluation for Shaker Heights City School District.

★★

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The Crawford Auto and Aviation Museum
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INTELLIGENCE & SCHOOLING

Addendum to Proceedings of Conference 2: November 17-18, 1983

Panelists

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Michael Aldridge, Director
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SUMMARIES

The panel was designed to shed light on many variables that are critical to the development of intelligence.

Dr. Allan McLeod focused upon the importance of emotions and the affect in the school environment. He has over 16 years of experiences in public schools with both elementary and secondary students and teachers.

Dr. Jane Kessler provided information about intelligence in the very young by describing three research projects. Dr. Kessler is the author of an outstanding textbook in the field of psychology, Psychopathology of Childhood and is the originator and past director of The Mental Development Center at Case Western Reserve University.

Michael Aldridge offered us a view of training adults from the private sector and from a high-tech industry. As the director of recruitment, a major issue for him is the shortage of intelligent, bright applicants who have some background with new technologies. His company must turn down many applicants because they have not taken math and science courses beyond the 10th grade.

Carmen Cancel focused upon cultural aspects of developing intelligence and potential of youngsters. She gave us examples of the impact of the traditional school organization and curriculum upon children from different cultural and language backgrounds.

On the following pages are excerpts from the presentations by each panelist.

As we focus upon getting the hard knowledge and the basics to our students, I am concerned about the "soft" knowledge and the learning environments we create in our schools.

There are some serious concerns about the strong affects which get in the way of learning and functioning. Schools don't deal with this issue very much because we don't understand these issues well. Maybe we should be including the affects as part of the basics.

Because we forget about the emotional environment of the schools, we do not use what we know about these affects and emotions to help children be more successful in developing their potential. For example, we know about the impact of divorce upon children.... there can be a loss of two years of learning. Other losses like death and even moving to another state can have that same impact on a child. What do we do in schools to alter our expectations of such children and to help us all cope with these situations?

We know there are critical periods in life--and in the very early years. Schools do very little in that area with children at young ages or with parents.

Futhermore, we should try to decide how and when we should intervene as educators. We could at least recognize that all learning occurs in emotional states.

A recent study of college-age youth was trying to discover what elements are important for success through the young years. There were five distinct factors: intelligence, grades, perseverance a high hostility quotient, and many interests.

In meetings like this conference, perhaps we can start to deal with these concerns about incorporating more of our knowledge of these "soft" areas into the total school programs.

Dr. Jane Kessler

There are three research projects dealing with the study of intelligence in very young children that I will share with you today. The first project had as its subjects 3-month old infants. The researchers found that in the areas of discrimination, recognition and responses, the infants scores correlated to scores of children age 12 years old on a WISC.

The second project focused on 3 and 4 year old children in a school setting. The same children were followed in their schooling through the second grade. Behaviors studied were in two categories: 1) interest and participation, and 2) cooperation and compliance. Those 3 and 4 year old children who were higher in interest and participation were found to be higher achievers in second grade than those children whose scored higher in cooperation and compliance.

The third research project involved slow-learning adolescents. Using a pre/post research design, individual interventions were done with the subjects. The data clearly indicate that there were permanent changes in the learning rates of the subjects. This shows that there is more than one critical period for learners.

In summary, intelligence behaviors are characterized by words such as "active" not passive, "noticing," and "doing". Learning environments that will enhance development of intelligence are those that involve the child in a relationship with the teacher and where the child helps to establish the goals.

Michael Aldridge

From the point of view of a private sector industry, there is a shortage of intellectual, bright applicants for jobs. Most applicants have had no experiences with new technologies. Even though there are on-the-job training and adult re-training programs, it is difficult to find appropriate employees because most applicants have not studied math and science courses beyond the 10th grade. A recent study nationwide shows that 85% of students do not take higher level science and math courses in high school.

Recommendations from various reports that I agree with are the adopt-a-school approach, lengthening the school day, developing programs that would get high school students into corporations, and upgrading teacher quality and expertise.

However, industries will not get involved to any significant degree in school programs and change until educators have reflected and decided what schools are supposed to be doing. Those decisions will determine what industries can do and how they can get involved in schooling.

Carmen Cancel

My purpose today is to bring out the cultural aspects of the issues being studied at this conference. First, we need to get away from a "mainstream mentality." The mainstream does not exist anymore. Cleveland is an excellent example of the diversity of our society and many communities across the nation. Cleveland also is an example of the kinds of challenges now facing all of us.

We need to get away from the idea that language differences mean stupidity and that there are "groups" that go quicker through school programs and get into that mainstream program faster than other groups.

We should recognize the impact of the cultural background of each student, including the motivational differences within those cultures. The use and value of education is different from culture to culture. An example is the way various immigrant groups evolve and under what circumstances that immigrant group is here in Cleveland. Their view about why there are here, perhaps leaving a war experience, will impact upon the way they use and value formal education.

Every society sets up its institutions to foster the dominant values that pervade that society. Our own society has changed and is changing again to one that is multi-cultural and includes many people speaking a variety of languages.

There are two specific thoughts I would like to leave you with today. One deals with the impact of technologies which increases the need for all of our students to master the English language and to have at least a high school education.

The other deals with the critical period for these children: when they sit and smile and are placid, that indicates that "lost" feeling....and we know that these feelings retard learning.